Alaska Sablefish Assessment for 2005

By

Michael F. Sigler, Chris R. Lunsford, Jeffrey T. Fujioka, and Sandra A. Lowe

3.0 Executive Summary

3.0.1 Summary of major changes

Relative to last year's assessment, we made the following substantive changes in the current assessment.

Input data: Relative abundance and length data from the 2004 longline survey, relative abundance and length data from the 2003 longline fishery, and age data from the 2003 longline survey and longline fishery were added to the assessment model.

Assessment results: Sablefish abundance increased during the mid-1960's due to strong year classes from the 1960's. Abundance subsequently dropped during the 1970's due to heavy fishing; catches peaked at 56,988 mt in 1972. The population recovered due to strong year classes from the late 1970's; spawning abundance peaked again in 1987. The population then decreased because these strong year classes are dying off.

The survey abundance index decreased 5% from 2003 to 2004 and follows an 8% decrease from 2002 to 2003. These decreases follow recent increases, so that relative abundance in 2004 is 4% higher than in 2000. The fishery abundance index decreased 12% from 2002 to 2003 (the 2004 data isn't available yet). The decrease follows recent increases, so that relative abundance in 2003 is 6% lower than in 2000.

Spawning biomass is projected to decrease slightly (2%) from 2004 to 2005. **Sablefish abundance is moderate; projected 2005 spawning biomass is 37% of unfished biomass.** Abundance has increased from a low of 33% of unfished biomass during 1998 to 2000. The 1997 year class is an important part of the total biomass and is projected to account for 23% of 2005 spawning biomass. The 2000 year class likely is above average although more years of data are needed to confirm its strength. The 1998 year class, once expected to be strong, appears average.

Sablefish are managed under Tier 3 of NPFMC harvest rules. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from this assessment are 223,000 t (combined across the EBS, AI, and GOA), 0.112, and 0.136, respectively. Projected spawning biomass (combined areas) for 2005 is 204,000 t (92% of $B_{40\%}$), placing sablefish in sub-tier "b" of Tier 3. The maximum permissible value of F_{ABC} under Tier 3b is 0.102 which translates into a 2005 catch (combined areas) of 21,000 t. The OFL fishing mortality rate is 0.124 which translates into a 2005 OFL (combined areas) of 25,400 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

We recommend a 2005 ABC of 21,000 mt. The maximum permissible yield for 2005 from an adjusted $F_{40\%}$ strategy is 21,000 mt. The maximum permissible yield for 2005 represents a decrease (9%) from the 2004 ABC of 23,000 mt and is similar to the 2003 ABC of 20,900 mt. Spawning biomass is projected to decrease from 2004 to 2005 (2%).

Spawning biomass currently is at 37% of the unfished level, but is projected to fall to 35% of the unfished level by 2007. Abundance is projected to fall because year classes following the strong 1997 year class are weaker than the 1997 year class. The maximum permissible ABC also is projected to decline to 19,900 mt in 2006 and 18,500 mt in 2007.

The risk that maximum permissible yield will reduce spawning biomass below the replacement level is low. During the next three years, the probability of spawning biomass falling below the estimated threshold of $B_{18\%}$ and the NMFS definition of MSST for a Tier 3 stock of $B_{17.5\%}$ is nil. The probability of falling below the threshold when resiliency is unknown of $B_{30\%}$ in three years is small (0.06). The long-term probability depends on future recruitment, but will be updated each year as new data becomes available.

In December 1999, the Council allocated the 2000 ABC and OFL based on a 5-year exponential weighting of the survey and fishery abundance indices. We used the same algorithm to allocate the 2005 ABC and OFL.

Area	ABC	Change	OFL	Age-4+ biomass
Total	**21,000**	-9%	25,400	253,000
Bering Sea	**2,440**	-19%	2,950	34,000
Aleutians	**2,620**	-24%	3,170	34,000
Gulf of Alaska	**15,940**	-4%	19,280	185,000
Western	**2,540**	-13%		
Central	**7,250**	-1%		
W. Yakutat	**2,390**	2%		
E. Yakutat / Southeast	**3,760**	-5%		

After the adjustment for the 95:5 hook-and-line:trawl split in the Eastern Gulf of Alaska, the ABC for West Yakutat is 2,580 mt and for East Yakutat / Southeast is 3,570 mt.

3.0.2 Responses to Council, SSC, and Plan Teams comments

The SSC supports last year's decision analysis, which considers Council established harvest policies. This analysis adjusts catch with abundance when projecting abundance and analyzing the effect of catch. We continue to use the same approach to decision analysis and harvest projections as last year.

The Plan Teams recommended that the different selectivity of pots and longline gear should be explored because of the increased use of pots in the Bering Sea. We compared the length frequencies from the longline and pot fisheries (section 3.1.1).

3.1 Introduction

Distribution: Sablefish (*Anoplopoma fimbria*) inhabit the northeastern Pacific Ocean from northern Mexico to the Gulf of Alaska, westward to the Aleutian Islands, and into the Bering Sea (Wolotira et al 1993). Adult sablefish occur along the continental slope, shelf gullies, and in deep fjords, generally at depths greater than 200 m. Sablefish observed from a manned submersible were found on or within 1 m of the bottom (Kreiger 1997).

Stock structure and management units: Sablefish form two populations based on differences in growth rate, size at maturity, and tagging studies (McDevitt 1990, Saunders et al. 1996, Kimura et al. 1998). A northern population inhabits Alaska and northern British Columbia waters and a southern population inhabits southern British Columbia and Washington, Oregon and California waters, with mixing of the two populations occurring off southwest Vancouver Island and northwest Washington.

Sablefish are assessed as a single population in Federal waters off Alaska because northern sablefish are highly migratory for at least part of their life (Heifetz and Fujioka, 1991; Maloney and Heifetz, 1997; Kimura et al. 1998). Sablefish are managed by discrete regions to distribute exploitation throughout their wide geographical range. There are four management areas in the Gulf of Alaska: Western, Central, West Yakutat, and East Yakutat/Southeast Outside (SEO) and two management areas in the Bering Sea/Aleutian Islands (BSAI): the eastern Bering Sea (EBS) and the Aleutian Islands region.

Early life history: Spawning is pelagic at depths of 300-500 m near the edges of the continental slope

(McFarlane and Nagata 1988), with eggs developing at depth and larvae developing near the surface as far offshore as 180 miles (Wing 1997). Average spawning date based on otolith analysis is March 30 (Sigler et al. 2001). During surveys of the outer continental shelf, most young-of-the-year sablefish are caught in the central and eastern Gulf of Alaska (Sigler et al. 2001). Near the end of the first summer, pelagic juveniles less than 20 cm drift inshore and spend the winter and following summer in inshore waters, reaching 30-40 cm by the end of their second summer (Rutecki and Varosi 1997). After their second summer, they begin moving offshore, typically reaching their adult habitat, the upper continental slope at 4 to 5 years.

3.1.1 Fishery

Early U.S. fishery, 1976 and earlier

Sablefish have been exploited since the end of the 19th century by U.S. and Canadian fishermen. The North American fishery on sablefish developed as a secondary activity of the halibut fishery of the United States and Canada. Initial fishing grounds were off Washington and British Columbia and then spread to Oregon, California, and Alaska during the 1920's. Until 1957, the sablefish fishery was exclusively a U.S. and Canadian fishery, ranging from off northern California northward to Kodiak Island in the Gulf of Alaska; catches were relatively small, averaging 1,666 mt from 1930 to 1957, and generally limited to areas near fishing ports (Low et al 1976).

Foreign fisheries, 1958 to 1987

Japanese longliners began operations in the eastern Bering Sea in 1958. The fishery expanded rapidly in this area and catches peaked at 25,989 mt in 1962 (Table 3.1, Figure 3.1). As the fishing grounds in the eastern Bering were preempted by expanding Japanese trawl fisheries, the Japanese longline fleet expanded to the Aleutian Islands region and the Gulf of Alaska. In the Gulf of Alaska, sablefish catches increased rapidly as the Japanese longline fishery expanded, peaking at 36,776 mt overall in 1972. Catches in the Aleutian Islands region remained at low levels with Japan harvesting the largest portion of the sablefish catch. Most sablefish harvests were taken from the eastern Being Sea until 1968, and then from the Gulf of Alaska until 1977. Heavy fishing by foreign vessels during the 1970's led to a substantial population decline and fishery regulations in Alaska which sharply reduced catches. Catch in the late 1970's was restricted to about one-fifth of the peak catch in 1972.

Japanese longliners had a directed fishery for sablefish. Sasaki (1985) described the gear used in the directed Japanese longline fishery. He found only minor differences in the structure of fishing gear and the fishing technique used by Japanese commercial longline vessels. There were small differences in the length of hachis (Japanese term for a longline skate) and in the number of hooks among vessels, but hook spacing remained about 1.6 m. The use of squid as bait by vessels also remained unchanged, except some vessels used Pacific saury as bait when squid was expensive. The standard number of hachis fished per day was 376 (Sasaki 1978) and the number of hooks per hachi was 43 until 1979, when the number was reduced to 40 (T. Sasaki, Japan Fisheries Agency, 4 January 1999).

Japanese trawlers caught sablefish mostly as bycatch in fisheries targeting other species. Two trawl fisheries catching sablefish in the Bering Sea through 1972, the North Pacific trawl fishery which caught sablefish as bycatch to the directed pollock fishery and the land-based dragnet fishery that sometimes targeted sablefish (Sasaki 1973). The latter fishery mainly targeted rockfishes, Greenland turbot, and Pacific cod, and only a few vessels targeted sablefish (Sasaki 1985). The land-based fishery caught more sablefish, averaging 7,300 mt from 1964 to 1972, compared to the North Pacific trawl fishery, which averaged 4,600 mt. In the Gulf of Alaska, sablefish were caught as bycatch to the directed Pacific Ocean perch fishery until 1972, but some vessels started targeting sablefish in 1972 (Sasaki 1973). Most net-caught sablefish were caught by stern trawls, but significant amounts also were caught by side trawls and

Danish seines the first few years of the Japanese trawl fishery.

Other foreign nations besides Japan also have caught sablefish. Substantial U.S.S.R. catches were reported from 1967-73 in the Bering Sea (McDevitt 1986). Substantial R.O.K. catches were reported from 1974-1983 scattered throughout Alaska. Other countries reporting minor sablefish catches were Republic of Poland, Taiwan, Mexico, Bulgaria, Federal Republic of Germany, and Portugal. The U.S.S.R. gear was factory-type stern trawl and the R.O.K. gear was longlines and traps (Low et al 1976).

Recent U.S. fishery, 1977 to present

The U.S. longline fishery began expanding in 1982 in the Gulf of Alaska and in 1988, harvested all sablefish taken in Alaska except minor joint venture catches. Following domestication of the fishery, the previously year-round season in the Gulf of Alaska began to shorten in 1984. By the late 1980's, the average season length decreased to one to two months. In some areas, this open-access fishery was as short as 10 days, warranting the label “derby” fishery.

Year	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**
Season length (months)	12	7.6	3.0	1.5	1.2	1.8	1.5	1.3	0.9	0.7	0.5	0.3

Season length continued to decrease until Individual Fishery Quotas (IFQ) were implemented for hook-and-line vessels in 1995 along with an 8-month season. The season ran from March 15-November 15 until 2003, when the starting date was changed to March 1 to extend the season to 8-1/2 months. The sablefish IFQ fishery is concurrent with the halibut IFQ fishery.

The expansion of the U.S. fishery was helped by exceptional recruitment during the late 1970's. This exceptional recruitment fueled an increase in abundance for the population which had been heavily fished during the 1970's. Increased abundance led to relaxation of fishing quotas and catches peaked again in 1988 at about 70% of the 1972 peak. Abundance has since fallen as the exceptional late 1970's year classes have died off. Catches also have fallen and in 2000, were about 42% of the 1988 peak.

IFQ management has increased fishery catch rate and decreased the harvest of immature fish (Sigler and Lunsford 2001). Catching efficiency increased 1.8 times with the change from an open-access to an IFQ fishery. The improved catching efficiency of the IFQ fishery reduced variable costs to catch the quota from eight to five percent of landed value, a savings averaging US$3.1 million annually. Decreased harvest of immature fish improved the chance that individual fish will reproduce at least once. Spawning potential of sablefish, expressed as spawning biomass per recruit, increased nine percent for the IFQ fishery.

The directed fishery primarily is a hook-and-line fishery. Sablefish also are caught as bycatch during directed trawl fisheries for other species groups such as rockfish and deepwater flatfish. Five state fisheries land sablefish outside the IFQ program; the major State fisheries occur in the Prince William Sound, Chatham Strait, and Clarence Strait and the minor fisheries in the northern Gulf of Alaska and Aleutian Islands. The minor state fisheries were established by the State of Alaska in 1995, the same time as the Federal Government established the IFQ fishery, primarily to provide open-access fisheries to fishermen who could not participate in the IFQ fishery. For Federal and State sablefish fisheries combined, the number of longline vessels targeting sablefish (Hiatt and Terry 2002) was:

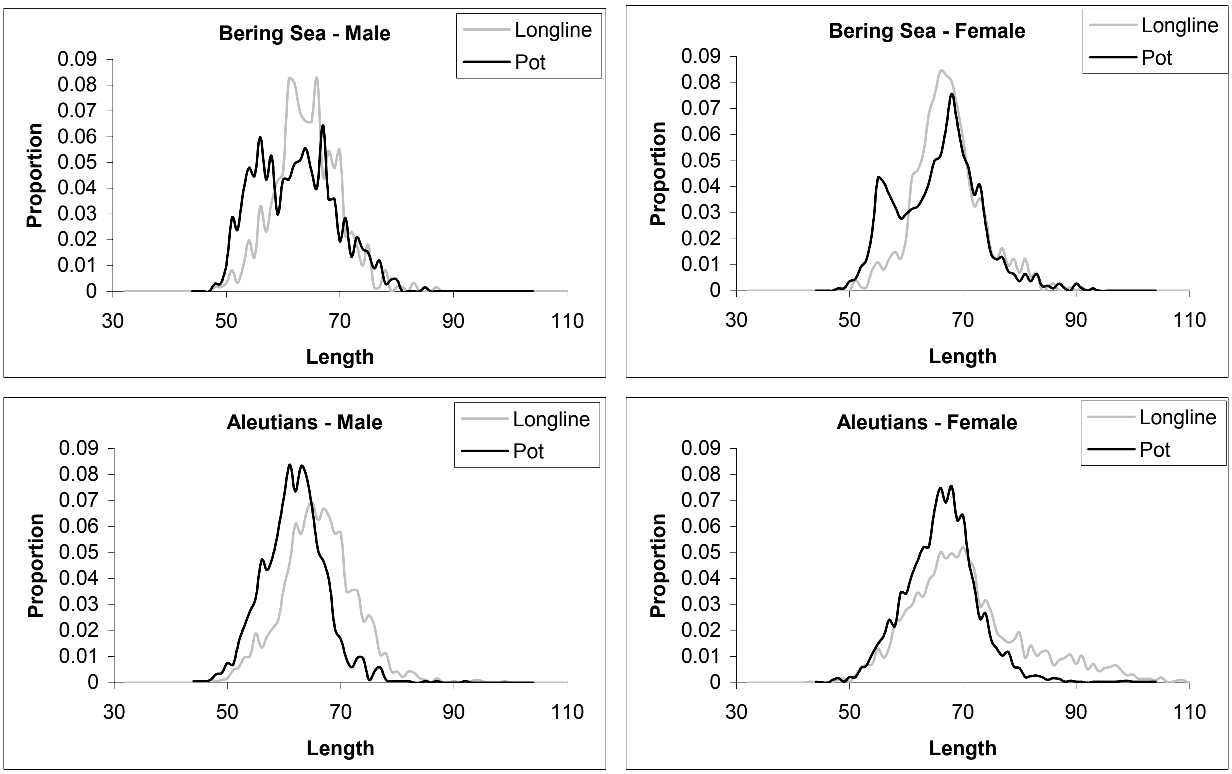
Year	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Vessels	871	1,078	613	578	504	450	446	436	438	421	408

The numbers of hooks deployed in the Federal fishery alone were:

Year	Aleutians	Bering Sea	Western Gulf	Central Gulf	Eastern Gulf	Total
1990	6.5	9.7	5.9	40.1	34.6	96.9
1991	8.7	5.6	7.2	30.7	25.7	78.0
1992	7.6	4.5	14.3	28.7	29.8	84.9
1993	12.9	7.5	4.0	33.3	29.1	86.7
1994	9.9	2.3	2.7	25.1	41.6	81.5
1995	8.2	3.7	7.3	14.4	16.4	50.1
1996	7.1	3.2	6.7	12.8	15.2	45.1
1997	5.2	4.1	5.7	10.6	8.8	34.4
1998	4.8	3.9	5.7	11.4	9.2	35.0
1999	4.0	5.4	5.1	10.6	8.1	33.2
2000	9.0	6.0	5.6	12.9	9.9	43.4
2001	7.2	1.8	6.4	12.4	11.2	39.1
2002	7.7	8.7	6.4	12.8	8.9	44.5
2003	23.3	30.2	8.1	13.2	8.4	83.1

Longline gear in Alaska is fished on-bottom. In the 1996 directed fishery for sablefish, average set length was 9 km and average hook spacing was 1.2 m. The gear is baited by hand or by machine, with smaller boats generally baiting by hand and larger boats generally baiting by machine. Circle hooks usually are used, except for modified J-hooks on some boats with machine baiters. The gear usually is deployed from the vessel stern with the vessel traveling at 5-7 knots. Some vessels attach weights to the longline, especially on rough or steep bottom, so that the longline stays in place and lays on-bottom.

Pot fishing for sablefish has increased in the Bering Sea and Aleutian Islands as a response to depredation of longline catches by killer whales. The Plan Teams recommended that the different selectivity of pots and longline gear should be explored because of the increased use of pots in the Bering Sea. We compared the length frequencies from the 2003 longline and pot fisheries. Pot gear catches fewer large fish than longline gear.



Catch

Annual catches in Alaska averaged about 1,700 mt from 1930 to 1957 and exploitation rates remained low until Japanese vessels began fishing for sablefish in the Bering Sea in 1959 and the Gulf of Alaska in 1963. Catches rapidly escalated during the mid-1960's. Annual catches in Alaska reached peaks in 1962, 1972, and 1988 (Table 3.1). The 1972 catch was the all-time high, at 53,080 mt, and the 1962 and 1988 catches were 50% and 72% of the 1972 catch. Evidence of declining stock abundance led to significant fishery restrictions from 1978 to 1985, and total catches were reduced substantially. Catches averaged about 12,200 mt during this time. Exceptional recruitment fueled increased abundance and increased catches during the late 1980's. The domestic fishery also expanded during the 1980's, harvesting 100% of the catch in the Gulf of Alaska by 1985 and in the Bering Sea and Aleutians by 1988. Catches have declined during the 1990's. Catches peaked at 38,406 mt in 1988 and have fallen to about 16,000 mt currently due to reduced quotas.

Bycatch and discards

Sablefish discards averaged 526 mt (3.7% of total catch) in longline fisheries and 560 mt (29.8%) in trawl fisheries during 1998-2002 (Table 3.2). By longline fishery, discards averaged 380 mt (2.8%) in the sablefish fishery, 63 mt (29.7%, BSAI) in the Greenland turbot fishery, and 32 mt (44.4%, BSAI) in the Pacific cod fishery. By trawl fishery, discard averaged 225 mt (20.8%) in rockfish fisheries and 285 mt (41.1%) in flatfish fisheries.

Previous management actions

Quota allocation: Amendment 14 to the Gulf of Alaska Fishery Management Plan, allocated the sablefish quota by gear type: 80% to hook-and-line gear and 20% to trawl in the Western and Central Gulf of Alaska and 95% to hook-and-line gear and 5% to trawl in the Eastern Gulf of Alaska, effective 1985. Amendment 13 to the Bering Sea/Aleutian Islands Fishery Management Plan, allocated the sablefish quota by gear type, 50% to fixed gear and 50% to trawl in the eastern Bering Sea, and 75% to fixed gear and 25% to trawl gear in the Aleutians, effective 1990.

IFQ management: Amendment 20 to the Gulf of Alaska Fishery Management Plan and 15 to the Bering Sea/Aleutian Islands Fishery Management Plan established IFQ management for sablefish beginning in 1995. These amendments also allocated 20% of the fixed gear allocation of sablefish to a CDQ reserve for the Bering Sea and Aleutian Islands.

Maximum retainable allowances: Maximum retainable allowances for sablefish were revised in the Gulf of Alaska by a regulatory amendment, effective 10 April 1997. The percentage depends on the basis species: 1% for pollock, Pacific cod, Atka mackerel, "other species", and aggregated amount of non-groundfish species. Fisheries targeting deep flatfish, rex sole, flathead sole, shallow flatfish, Pacific ocean perch, shortraker and rougheye rockfish, other rockfish, northern rockfish, pelagic rockfish, demersal shelf rockfish in the Southeast Outside district, and thornyheads are allowed 7%. Arrowtooth flounder fisheries are not allowed to retain any sablefish.

Allowable gear: Amendment 14 to the Gulf of Alaska Fishery Management Plan banned the use of pots for fishing for sablefish in the Gulf of Alaska, effective 18 November 1985, starting in the Eastern area in 1986, in the Central area in 1987, and in the Western area in 1989. An earlier regulatory amendment was approved in 1985 for 3 months (27 March - 25 June 1985) until Amendment 14 was effective. A later regulatory amendment in 1992 prohibited longline pot gear in the Bering Sea (57 FR 37906). The prohibition on sablefish longline pot gear use was removed for the Bering Sea, except from 1 to 30 June to prevent gear conflicts with trawlers during that month, effective 12 September 1996. Sablefish longline pot gear is allowed in the Aleutian Islands.

Management areas: Amendment 8 to the Gulf of Alaska Fishery Management Plan established the West and East Yakutat management areas for sablefish, effective 1980.

3.1.2 Data

The following table summarizes the data used for this assessment:

Source	Data	Years
Fisheries	Catch	1960-2004
Japanese longline fishery	Effort	1964-1981
	Length	1963-1980
Japanese trawl fishery	Length	1964-1971
U.S. longline fishery	Effort, length	1990-2003
	Age	1999-2003
U.S. trawl fisheries	Length	1990,1991,1999
U.S. fisheries	Discards	1990-2004
Japan-U.S. cooperative longline survey	Catch, effort, length	1979-1994
	Age	1981, 1983, 1985, 1987, 1989, 1991, 1993
Domestic longline survey	Catch, effort, length	1990-2004
	Age	1996-2003

Fishery

Catch, effort, and length data are collected from sablefish fisheries. The catch data covers several decades. Length and effort data were collected from the Japanese and U.S. longline fisheries (Table 3.3). Length data were collected from the Japanese and U.S. trawl fisheries. The Japanese data were collected by fishermen trained by Japanese scientists (L-L. Low, Alaska Fisheries Science Center, 25 August 1999). The U.S. fishery data were collected by at-sea and plant observers. No age data were systematically collected from the fisheries until 1999 because of the difficulty of obtaining representative samples from the fishery and because a limited number of sablefish can be aged each year. The equations used to compile the fishery and survey data used in the assessment are shown in the 2002 SAFE (Appendix A).

The catches used in this assessment (Table 3.1) include catches from minor state waters fisheries in the northern Gulf of Alaska and in the Aleutian Islands region because fish caught in these state waters are reported using the area code of the adjacent Federal waters in Alaska Regional Office catch reporting system (G. Tromble, 12 July 1999), the source of the catch data used in this assessment. Minor state fisheries catches averaged 180 mt from 1995-1998 (ADFG), about 1% of the average total catch of 16,890 mt. Most of the catch (80%) is from the Aleutian Islands region. The effect of including these state waters catches in the assessment is to overestimate biomass by about 1%, a negligible error considering statistical variation in other data used in this assessment.

Some catches probably were not reported during the late 1980's (Kinoshita et al 1995). Unreported catches could account for the Japan-U.S. cooperative longline survey index's sharp drop from 1989-90 (Table 3.4, Figures 3.2 and 3.3). We tried to estimate the amount of unreported catches by comparing reported catch to another measure of sablefish catch, sablefish imports to Japan, the primary buyer of sablefish. However the trends of reported catch and imports were similar, so we decided to change our approach for catch reporting in the 1999 assessment. We assumed that non-reporting is due to at-sea discards and apply discard estimates from 1994 to 1997 to inflate U.S. reported catches before 1994 (2.9% for hook-and-line and 26.6% for trawl).

One problem with the fishery data has been low length sample sizes for the trawl fishery (Table 3.4). From 1992 to 1998, few lengths were collected each year and the resultant length frequencies were ragged and could not be used in the assessment model. The problem was that sablefish often are caught with other species like rockfish and deepwater flatfish, but are not the predominant species. The observer sampling protocol called for sampling the predominant species, so sablefish were poorly sampled. We communicated this problem to the observer program and together worked out revised sampling protocols. The revision greatly improved the sample size, so that the 1999 length data for the trawl fishery can be used for the assessment. Unfortunately the sample size decreased in 2000, falling from 1,268 lengths to 472 lengths, and the subsequent length compositions can not be used for the assessment. Small sample sizes for the trawl fishery continue to be a problem.

Longline fishery catch rate

Steady declines in longline survey catch rates of sablefish have led to reduced fishery quotas in recent years. Some fishermen are concerned that their catch rates have remained strong in some areas despite the decline in longline survey catch rates. Extensive fishery information is available from the observer program and logbooks. We computed fishery catch rates based on observer and logbook data and compared these fishery catch rates to longline survey data. We checked and did not find any substantial changes in fishery effort by season or area. Such changes may cause fishery catch rates to be unrepresentative of abundance. For example, fishermen sometimes target concentrations of fish, even as geographic distribution shrinks when abundance declines (Crecco and Overholtz 1990). Overfishing of northern (Newfoundland) cod likely was made worse by an incorrect interpretation of fishery catch rates: assessment scientists did not realize that the area occupied by the stock was diminishing while the fishery catch rates remained level (Rose and Kulka 1999).

Fishery data is recorded by observers and in voluntary and required logbooks. Vessels over 60 feet carry an observer 30% of the time if less than or equal to 125 feet and 100% of the time if over 125 feet. Logbooks are required for vessels over 60 feet. Some captains of vessels less than 60 feet participate in a voluntary logbook program initiated in 1997.

Only sets targeting sablefish are included, defined as a set where sablefish were at least 50% of the catch by weight. The logbook reported weights usually are approximate because vessel captains typically estimate and record catch for each set in the logbook while at sea and without an accurate scale measurement. An accurate weight for the entire trip is measured at landing and recorded as the IFQ landing report. We adjusted the captain’s estimate of catch per set using the ratio of IFQ landing report and logbook reported weight.

Hook spacing was standardized to a 39 inch (1 m) spacing following the method used for standardizing halibut catch rates (Skud and Hamley, 1978; Sigler and Lunsford, 2001). 39 and 42 inch spacings were the most common in the directed sablefish fishery (64% of all sets from 1990 to 1999). Each set’s catch rate was calculated by dividing the catch in weight by the standardized number of hooks, then used to compute average catch rates by vessel and NPFMC region. The observer and voluntary logbook data were combined when computing average catch rates. The required logbook data were available for the first time in 1999. Currently they are treated as a separate data set and are not included in the assessment model. Recent logbook data is not yet available because the contractor keying the data is behind. When this data becomes available, the logbooks will likely be included in the assessment model.

The Central Gulf region has the most sets observed and the Bering Sea the least (Table 3.5). The voluntary logbook data is an important supplement to the observer data, especially in the West Yakutat and East Yakutat/Southeast areas. More sets were reported for required logbook data than observer data, especially in the Bering Sea and East Yakutat/Southeast areas. The number of sets and vessels in the

Bering Sea are especially low. The number of sets in the Aleutian Islands is higher than the Bering Sea but only represents twelve vessels in comparison to the Central Gulf which has 35 vessels in 2003. The addition of the recent required logbook data will greatly increase the sample sizes in these areas.

Fishery catch rates were highest in West Yakutat and East Yakutat/Southeast, closely followed by the Central Gulf, and substantially more than Western Gulf, Bering Sea, and Aleutian Islands (Figure 3.4). Catch rates increased in all areas between 1994 and 1995 due to implementation of the IFQ system. The fishery and survey abundance indices show similar trends in the Western Gulf and Central Gulf areas and are generally similar in the East Yakutat area except for a sharp increase in fishery catch rates since 2001. In the West Yakutat area, prior to 2001 the survey trend was downward and the fishery trend was flat or upward. Since 2001 both indices have increased. In the Bering Sea and Aleutian Islands regions, a sharp decrease in the fishery catch rates occurred in 2003 while the survey catch rates have remained steady.

Required logbook fishery catch rates are similar to observer fishery catch rates in the Aleutian Islands, Western Gulf, and East Yakutat/Southeast and especially Central Gulf (Figure 3.5, the area with the highest sample size. Catch rates are probably significantly different for the Bering Sea in 1999 and West Yakutat in 2000, since the confidence intervals do not include the means. The addition of logbook data from 2002 and 2003 may improve our estimate of fishery catch rates in the Bering Sea and Aleutian Islands.

We are now exploring why the catch rates in the Bering Sea and Aleutian Islands are low in recent years. Targeting of Greenland turbot, which co-occur with sablefish in the Bering Sea, may add variability to fishery catch rates. We are exploring the effect of declaring turbot or sablefish as the target species since separating these sets is difficult. Killer whales depredate longline catches, but catch data from these longline sets is excluded from our analysis. We currently are checking that whale depredated sets are excluded from our analysis. Finally, catches from pot fishing in the Bering Sea and Aleutian Islands have increased sharply in the last several years, thus reducing sample sizes from longline fishing. Pot fishing may affect longline fishery catch rates. Next year we plan to investigate the interactions between the pot and longline fisheries.

Longline surveys

Catch, effort, age, length, weight, and maturity data are collected during sablefish longline surveys. These longline surveys likely provide an accurate index of sablefish abundance (Sigler 2000). Japan and the United States conducted a cooperative longline survey for sablefish in the Gulf of Alaska annually from 1978 to 1994, adding the Aleutians Islands region in 1980 and the eastern Bering Sea in 1982 (Sasaki 1985, Sigler and Fujioka 1988). Since 1987, the Alaska Fisheries Science Center has conducted annual longline surveys of the upper continental slope, referred to as domestic longline surveys, designed to continue the time series of the Japan-U.S. cooperative survey (Sigler and Zenger 1989). The domestic longline survey began annual sampling of the Gulf of Alaska in 1987, biennial sampling of the Aleutian Islands in 1996, and biennial sampling of the eastern Bering Sea in 1997 (Rutecki et al 1997). The domestic survey also samples major gullies of the Gulf of Alaska in addition to sampling the upper continental slope. The order in which areas are surveyed was changed in 1998 to reduce interactions between survey sampling and short, intense fisheries. Before 1998, the order was Aleutians and/or Bering Sea, Western Gulf, Central Gulf, Eastern Gulf. Starting in 1998, the Eastern area was surveyed before the Central area. Longline survey catches are tabled in appendix B.

Length data were collected for all survey years and sablefish otoliths were collected for most survey years. Not all otoliths collections were aged until 1996, when annual ageing of samples began. Otolith collections were length-stratified from 1979-94 and random thereafter.

Kimura and Zenger (1997) compared the performance of the two surveys from 1988 to 1994 in detail, including experiments comparing hook and gangion types used in the two surveys. The abundance index for both longline surveys decreased from 1988 to 1989, the cooperative survey decreased from 1989 to

1990, while the domestic survey increased (Table 3.4). Kimura and Zenger (1997) attributed the difference to the domestic longline survey not being standardized until 1990.

Killer whale depredation of the survey's sablefish catches has been a problem in the Bering Sea since the beginning of the survey (Sasaki, 1987). The problem occurred mainly east of 170^{o} W in the eastern Bering Sea and to a lesser extent in the northeast Aleutians between 170^{o} W and 175^{o} W. The 1983 (Sasaki 1984), 1986 and 1987 (T. Sasaki, Far Seas Fisheries Research Laboratory) and 1988 Bering Sea abundance indices likely were underestimated, although sablefish catches were lower at all stations in 1987 compared to 1986, regardless of whether killer whales were present. Killer whale depredation has been fairly consistent since 1988. An analysis is planned as time permits to exclude killer whale affected stations from abundance calculations with the cooperative longline survey data. Portions of the gear affected by killer whale depredation during domestic longline surveys already are excluded from the analysis of the survey data.

Sperm whale depredation may affect longline catches. Data on apparent sperm whale depredation has been recorded since the 1998 longline survey (Table 3.6). Apparent sperm whale depredation is defined as sperm whales are present and damaged sablefish are retrieved. Sperm whales also are present when fish are retrieved undamaged (about 45% of the time), in which case the sperm whales apparently feed off offal. The number of stations with sperm whale depredation was four in 1998, twelve in 1999, five in 2000, and five in 2001. The number of damaged sablefish retrieved averaged eight per station. Sablefish catches were significantly less at affected stations. Standard residuals of relative population number (RPN) by station were significantly less at the affected stations (Mann-Whitney test (a nonparametric rank test), one-sided test, $p = 0.035$). The median standard residual for stations with depredation was -0.147 compared to 0.106 for unaffected stations, implying sperm whales removed twenty-three percent of the sablefish at stations where depredation occurred. Unlike our analysis, an earlier study found no significant effect (Hill et al. 1999). The earlier study compared longline fishery catches between sets with sperm whales present and absent. The likely reason they could not find a significant effect was that their analysis included all sperm whales sighted near the vessel, whether depredation occurred or not, thus tending to mask any effect.

The longline survey catch rates were not adjusted for sperm whale depredation because we don't know when significant depredation began. Current abundance is unbiased if depredation has consistently occurred over time. If significant depredation began recently, then current biomass is underestimated because the relationship between the survey index and biomass has changed. However if we adjust recent catch rates for sperm whale depredation when in fact it has happened all along, then current biomass will be overestimated. We do not plan to adjust longline survey catch rates for sperm whale depredation. We will continue to monitor sperm whale depredation of survey catches for changes in the level of depredation.

Interactions between longline fishery and survey are described in Appendix A.

Trawl surveys

Trawl surveys of the upper continental slope that adult sablefish inhabit have been conducted approximately triennially since 1979 in the Bering Sea, 1980 in the Aleutians, and 1984 in the Gulf of Alaska. Trawl surveys of the Eastern Bering Sea shelf are conducted annually. Juvenile sablefish of the 1977 year class were abundant on the shelf, but otherwise have been uncommon. The slope trawl surveys are not considered good indicators of the sablefish relative abundance over time because of differences in net types used each year, depths sampled, and high sampling variation and so are not used in the sablefish assessment. Trawl survey catches are tabled in appendix B.

Relative abundance trends – long-term

Relative abundance has cycled through three valleys and two peaks with peaks in about 1970 and 1985 (Table 3.4, Figures 3.2 and 3.3). The post-1970 decrease likely is due to heavy fishing. The 1985 peak likely is due to the exceptional late 1970's year classes. Since 1988, relative abundance has decreased substantially. Regionally, abundance decreased faster in the Eastern Bering Sea, Aleutian Islands, and western Gulf of Alaska and more slowly in the central and eastern Gulf of Alaska (Figure 3.6). These regional abundance changes likely are due to size-dependent migration. Small sablefish typically migrate westward, while large sablefish typically migrate eastward (Heifetz and Fujioka 1991). The recruitment of the strong late 1970s year classes accounted for the sharp increase in overall abundance during the early 1980s. During the late 1980s as sablefish moved eastward, abundance fell quickly in the western areas, fell slowly in the Central area, and remained stable in the Eastern area. The size-dependent migration and pattern of regional abundance changes indicate that the western areas are the outer edges of sablefish distribution and less favored habitat than the apparent center of sablefish abundance, the central and eastern Gulf of Alaska.

Above average year classes typically are first abundant in the western areas, another consequence of size-dependent migration. For example, an above average 1995 year class first became an important year class in western areas at age 4 (1999 plot), but not until age 7 (2002 plot) in the central and eastern areas (Figure 3.7). Overall, above average year classes became abundant in the western areas at ages 4-5, in the central area at ages 4-9, and in the eastern area at ages 4-7 (Table 3.7a). The strongest year classes (1977 and 1997) appear in the central and eastern areas at the earliest age (4), whereas the remaining above average year classes appear in these areas at later ages (6-9).

In the East Yakutat/Southeast area, sablefish abundance decreased for many years until 2002, when the fishery but not the survey index increased (Figure 3.4). The survey index has continued to generally decrease through 2004. This long-term decline in abundance for this area that is considered a part of the main spawning area (central and eastern Gulf of Alaska) is a serious concern.

Relative abundance trends – short-term

The survey abundance index decreased 5% from 2003 to 2004 and follows an 8% decrease from 2002 to 2003 (Table 3.4). These decreases follow recent increases, so that relative abundance in 2004 is 4% higher than in 2000. The fishery abundance index decreased 12% from 2002 to 2003 (the 2004 data isn't available yet). The decrease follows recent increases, so that relative abundance in 2003 is 6% lower than in 2000.

3.2 Analytic approach

3.2.1 Model structure

The sablefish population is represented with an age-structured model. The analysis follows the approach described by Kimura (1990) for age-structured population analysis. This approach also was described and tested for sablefish by Sigler (1999). The analysis was completed using AD model builder software, a C++ based software for development and fitting of general nonlinear statistical models (Otter Research 1996).

Parameters estimated independently

Age and Size of Recruitment: Juvenile sablefish rear in nearshore and continental shelf waters, moving to the upper continental slope as adults. Fish first appear on the upper continental slope, where the longline survey and longline fishery primarily occur, at age 2 and length about 50-53 cm fork length. Fish are susceptible to trawl gear at an earlier age than to longline gear because trawl fisheries usually occur on the continental shelf and shelf break inhabited by younger fish.

Growth and maturity: Sablefish grow rapidly in early life, growing 1.2 mm d^{-1} during their first spring and summer (Sigler et al. 2001). Within 100 days after first increment formation, they average 120 mm. They reach average maximum lengths and weights of 69 cm and 3.4 kg for males and 83 cm and 6.2 kg for females. Fifty percent of females mature at 65 cm, while 50 percent of males are mature at 57 cm (Sasaki 1985), corresponding to ages 6.5 years for females and 5 years for males (Table 3.8). The length (L)-age (t) functions are $L = 68.8 (1- e^{-0.167 (t - -5.8)})$ for males and $L = 82.8 (1- e^{-0.120 (t - -6.3)})$ for females (Sigler et al. 1997). The weight (W) - length function is $W = 0.00000474 L^{3.19}$ (Sasaki 1985, all areas).

Sablefish are difficult to age, especially those older than eight years (Kimura and Lyons 1991). To compensate, we use an ageing error matrix based on known-age otoliths (Heifetz et al. 1999). An age-length transition matrix also was used to translate predicted age frequencies into predicted length frequencies.

Maturity parameters were estimated independently of the assessment model and then incorporated into the assessment model as fixed values. The maturity (M) - length function is $M = 1 / (1 + e^{-0.40 (L - 57)})$ for males and $M = 1 / (1 + e^{-0.40 (L - 65)})$ for females. Maturity at age was computed using logistic equations fit to the length/maturity relationships shown in Sasaki (1985, Figure 23, Gulf of Alaska). A value of 0.4 is used for the slope parameter for maturity at length (cm) of 50 percent maturity.

Maximum age and natural mortality: Sablefish are long-lived; ages over 40 years are regularly recorded (Kimura et al. 1993). Reported maximum age for Alaska is 94 years (Kimura et al. 1998); the previous reported maximum was 62 (Sigler et al. 1997). Canadian researchers report age determinations up to 55 years (McFarlane and Beamish, 1983). A natural mortality rate of M=0.10 has been assumed for previous sablefish assessments, compared to M=0.112 assumed by Funk and Bracken (1984). Johnson and Quinn (1988) used values of 0.10 and 0.20 in a catch-at-age analysis and found that estimated abundance trends agreed better with survey results when M=0.10 was used.

It usually is necessary to treat natural mortality essentially as known in advance (Walters and Ludwig 1994). For sablefish assessments before 1999, natural mortality was assumed to equal 0.10. For assessments from 1999 to 2003, natural mortality was estimated rather than assumed to equal 0.10; the estimated value was about 0.10. For the 2004 assessment, a more detailed analysis of the posterior probability showed that natural mortality was not well-estimated by the available data. The posterior distribution of natural mortality was very wide, ranging to near-zero. The acceptance rate during MCMC runs was low, 0.10-1.15. Parameter estimates even for MCMC chains thinned to every 1000th value showed some serial correlation. Based on these results, for the 2004 assessment we assumed that we knew the approximate value of natural mortality very precisely (c.v. = 0.001 for prior probability distribution) and that the approximate value was 0.10.

Parameters estimated conditionally

The age range for the model is 2 to 31, where 31 is a pooled group including all ages 31 and greater. Abundances for years 1960 to 2004 are estimated.

Selectivity is represented using a function and is separately estimated for longline survey, longline fishery, and trawl fishery. Selectivity for longline survey and longline fishery is restricted to be asymptotic. Selectivity for trawl fishery is allowed to be dome-shaped. The age of 50% availability for longline fisheries is allowed to differ with season length. Fishermen may choose where they fish in the IFQ fishery, compared to the crowded fishing grounds during the 1985-1994 “derby” fishery, when fishermen reportedly often fished in less productive depths due to crowding. In choosing their ground, they presumably target bigger, older fish.

Catchability is separately estimated for the Japanese longline fishery, the cooperative longline survey, the domestic longline survey, and the U.S. longline fishery. Information is available to link these estimates of catchability. Kimura and Zenger (1997) analyzed the relationship between the cooperative and domestic longline surveys. We used their results to create a prior distribution which linked catchability estimates for the two surveys. Sasaki (1979) and Sigler and Lunsford (2001) conducted hook spacing experiments. The fishery and survey data differ in their hook spacing but otherwise are similar. We used the hook spacing data to create prior distributions which linked the catchability estimates for the surveys and fisheries.

Bayesian analysis

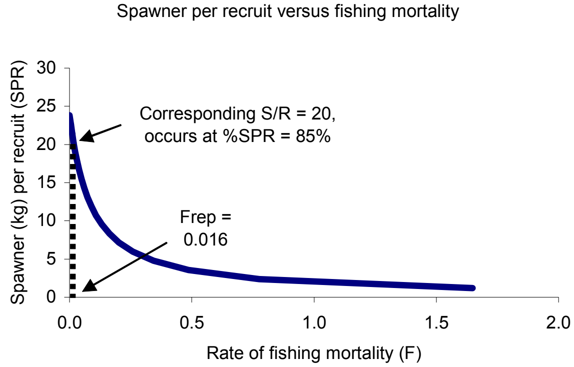
Since the 1999 assessment, we developed a limited Bayesian analysis that considered uncertainty in the value of natural mortality as well as survey catchability. In this assessment, we developed a full Bayesian analysis that additionally considers uncertainty in the remaining model parameters, as well as natural mortality and survey catchability. The multidimensional posterior distribution is mapped by Bayesian integration methods. The posterior distribution is computed based on 2 million Monte-Carlo Markov chain simulations drawn from the posterior distribution and thinned to 2,000 parameter “draws” to remove serial correlation between successive “draws”.

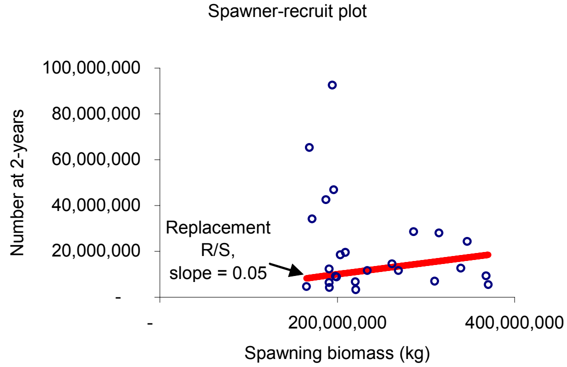
Decision analysis

We estimated the posterior probability that projected abundance will fall below thresholds of 20, 30, and 35% of the unfished spawning biomass based on the posterior probability estimates. Abundance was projected for 14 years. In the projections, future recruitments varied over the estimated range for the 1977-2000 year classes.

The choice of threshold depends on a determination of how much spawning per recruit is enough for successive generations to replace or surpass each other on average (Mace and Sissenwine 1993). Mace and Sissenwine (1993) described three methods of estimating overfishing thresholds. In the following discussion for sablefish, percent spawner per recruit (%SPR) and percent of unfished biomass are equivalent.

1) The threshold can be estimated from spawner-recruit data (Mace and Sissenwine 1993, Figure 1). The replacement spawner per recruit (20) was estimated as the inverse of the median survival ratio (0.05) from the spawner-recruit plot. The corresponding estimate of replacement fishing mortality (0.016) was then obtained from the spawners per recruit versus fishing mortality curve. The estimate of percent spawn per recruit (85%) is high because there are no observations of recruitment at very low stock sizes where recruitment is reduced due to low abundance (historic low was about 30% of unfished value). The estimate is unrealistic because the sablefish stock has been fished at much higher rates and been sustainable. This estimate is not used further.





2) The threshold can be estimated from regression relationships for other well-studied fisheries (Mace and Sissenwine 1993, Table 6). An estimate for replacement SPR = 18% was obtained for sablefish values of maximum weight of 5.3 kg, weight at 50% maturity of 2.4 kg, unfished biomass of 525,000 mt, and natural mortality of 0.107, and the regression coefficients in Mace and Sissenwine (1993, Table 6). The sablefish estimate of 18% is similar to the other species analyzed by Mace and Sissenwine (1993), which found a mean value of 18.7% and a median value of 17.2%. This value also is similar to 17.5%, the value to determine whether a stock is overfished for NPFMC Tier 3 stocks.
3) A default threshold of 30%SPR is recommended when there is no other basis for estimating the replacement level (Mace and Sissenwine 1993) or the resiliency of the stock is unknown (Mace 1994). Mace and Sissenwine (1993) found that a 30% level was enough for 80% of the fish stocks considered, but may be overly-conservative for an "average" stock. The threshold for sablefish abundance of 18%SPR was estimated from regression relationships for other well-studied fisheries. This estimate of resiliency at low stock levels is uncertain because the regression relationship may not apply to sablefish and there are no observations on how sablefish recruitment will respond below about 30% of the unfished level.

Mace (1994) conducted a theoretical examination of the relationship of commonly used thresholds and life history values. The theoretical study supports the previous recommendation by Mace and Sissenwine (1993), who recommended 20% of pristine biomass for stocks with at least average resilience (compensatory recruitment at low abundance) and 30% of pristine biomass for little-known stocks. Thompson (1993) provided additional guidance on threshold stock size and maximum fishing mortality rate: biomass should remain above $B_{20\%}$ (based on the stock-recruitment curve, not average historic recruitment); fishing mortality rate should remain below $F_{30\%}$.

In previous assessments, two recruitment time series have been used to project abundance, the 1977 and onward year classes and the 1982 and onward year classes. We excluded the 1977-1981 year classes from the second time series because these strong year classes were much stronger than successive year classes until the strong 1997 year class appeared. The average year class strength (number at age 2) is 44 million for the 1977-1981 year classes and 13 million for the 1982-1996 year classes. However the short-term difference in abundance projections between the two recruitment scenarios (1977 and onward vs. 1982 and onward) usually is small. In last year's assessment, spawning biomasses projected 3-years ahead (2006) differed by only 2% (maximum permissible fishing mortality) (Sigler et al. 2003). The benefits of fishing below the maximum permissible rate take several years to become apparent and whether the benefit is substantial depends on future average recruitment. **Thus in this year's assessment, we project abundance only with the 1977 and onward year classes.**

3.3 Model evaluation

The model fit the observed abundance indices, survey and fishery length data, and survey age data (Figures 3.2, 3.3, and 3.8 [the length fits are not shown for brevity]).

Abundance estimates for recent years from this assessment are lower than last year's (2003) assessment (Figure 3.9a). For example, estimated 2003 spawning biomass was 211,000 in the 2003 assessment and 202,000 in the 2004 assessment, a 4% difference. Nevertheless the abundance estimates for this year's assessment are within the range of estimates for the last several assessments (Figure 3.12). The reference point $B_{40\%}$ is higher, 211,000 mt in the 2003 assessment and 223,000 mt in the 2004 assessment, a 5% difference.

The years when strong year classes occurred during the 1960's changed in this year's assessment (Figure 3.9b). For example, the strong 1968 year class in this year's assessment was estimated to have occurred in 1967 in last year's assessment. Recruitment estimation is difficult for these year classes because the estimates depend on length data, which is an imprecise measure of age, and some variation is to be expected. In fact, the year class assigned for these three strong year classes has changed in earlier assessments. For example, a strong year class was estimated for 1963 in the 1999 assessment, for 1964 in the 2000 assessment, and for 1965 in this year's assessment.

3.4 Model results

Abundance trends

Sablefish abundance increased during the mid-1960's (Table 3.9, Figure 3.10) due to strong year classes from the 1960's. Abundance subsequently dropped during the 1970's due to heavy fishing; catches peaked at 56,988 mt in 1972. The population recovered due to strong year classes from the late 1970's; spawning abundance peaked again in 1987. The population then decreased because these strong year classes are dying off.

Spawning biomass is projected to decrease slightly (2%) from 2004 to 2005. Projected 2005 spawning biomass is 204,000 mt and exploitable biomass is 232,000 mt (Table 3.9). **Sablefish abundance is moderate; projected 2005 spawning biomass is 37% of unfished biomass.** Abundance has increased from a low of 33% of unfished biomass during 1998 to 2000 due to the strong 1997 year class. This year class is an important part of the total biomass and is projected to account for 23% of 2005 spawning biomass.

Recruitment trends

Annual estimated recruitment varies widely (Figure 3.11). Year classes were classified as "weak" if <80% of average and "strong" if >120% of average.

Strong	1960	1961	1965	1968	1977	1978	1980	1981	1984	1997	2000
Average	1974	1988	1990	1995							
Weak	1962	1963	1964	1966	1967	1969	1970	1971	1972	1973	1975
	1976	1979	1982	1983	1985	1986	1987	1989	1991	1992	1993
	1994	1996	1998	1999	2001	2002					

Two recent strong year classes are the 1997 and 2000 year classes, although more years of data are needed to confirm the strength of the 2000 year class. The 1998 year class, once expected to be strong (see section 3.1.2 for evidence) appears weak.

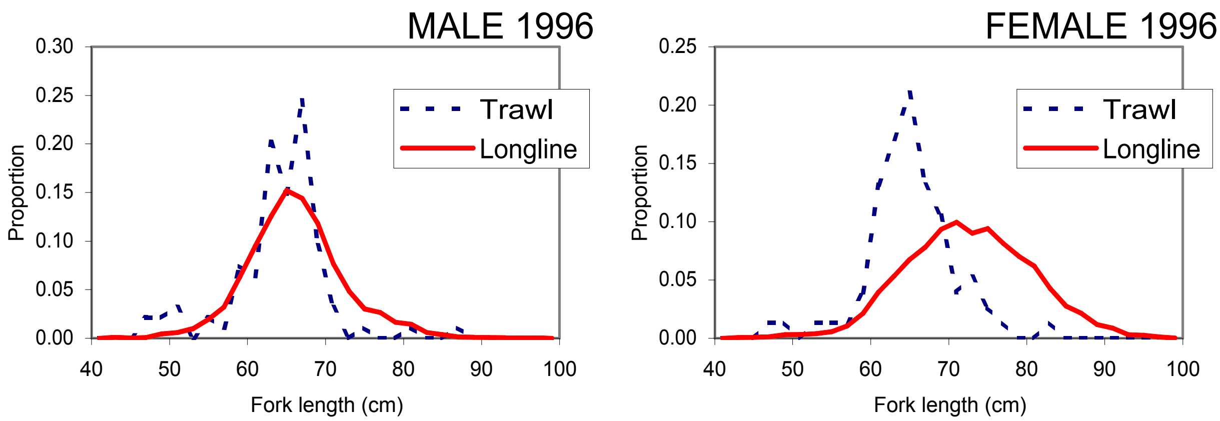
Average recruitment for the 1977-2000 year classes is 21 million 2-year old sablefish per year, slightly higher than the 19 million for the 1957-2000 year classes. Estimates of recruitment strength during the 1960's are uncertain because they depend on length rather than age data and because the abundance index is the fishery catch rate, which may be a biased measure of abundance.

Juvenile sablefish are pelagic and at least part of the population inhabits shallow near-shore areas for their first one to two years of life (Rutecki and Varosi 1997). In most years, juveniles are found only in a few places such as Saint John Baptist Bay near Sitka, Alaska. Widespread, abundant age-1 juveniles likely indicate a strong year class. Abundant age-1 juveniles were reported for the 1960 (J. Fujioka & H. Zenger, NMFS, approximate year), 1977 (Bracken 1983), 1980, 1984, and 1998 year classes in southeast Alaska, the 1997 and 1998 year classes in Prince William Sound (W. Bechtol, ADFG), and the 1998 year class near Kodiak Island (D. Jackson, ADFG). Observations of juvenile sablefish in annual surface gillnet surveys in the Aleutian Islands, Bering Sea and Gulf of Alaska, shows promise as an index of strong year classes. Catch rates of young-of-the-year sablefish imply that the 1995, 1997, and 1998 year classes are above average.

Sablefish recruitment varies greatly from year to year (Figure 3.11), but shows some relationship to environmental conditions. Sablefish recruitment success is related to winter current direction and water temperature; above average recruitment is more common for years with northerly drift or above average sea surface temperature (Sigler et al. 2001). Sablefish recruitment success also is related to recruitment success of other groundfish species. Strong year classes were synchronous for many northeast Pacific groundfish stocks for the 1961, 1970, 1977, and 1984 year classes (Hollowed and Wooster 1992). For sablefish in Alaska, the 1961, 1977, and 1984 year classes also were strong. Some of the largest year classes of sablefish occurred when abundance was near the historic low, the 1977-1978 and 1980-1981 year classes. These strong year classes followed the 1976/1977 North Pacific regime shift. The 1977 year class was associated with the Pacific Decadal Oscillation (PDO) phase change and the 1977 and 1981 year classes were associated with warm water and unusually strong northeast Pacific pressure index (NEPI, Hollowed and Wooster 1992). Some species such as walleye pollock and sablefish exhibit increased production at the beginning of a new environmental regime, when bottom up forcing prevails and high turnover species compete for dominance, which later shifts to top down forcing once dominance is established (Bailey 2001; Rice 2001; Hunt 2002). The large year classes of sablefish indicate that the population, though low, still was able to take advantage of favorable environmental conditions and produce large year classes.

Fishery selectivity and fishery catch rates

The age of 50% selection is 4.0 years for the longline survey and short open-access seasons (“derby” fishery), 4.6 years for the IFQ longline fishery, and 2.8 years for the trawl fishery (Figure 3.12). Selectivity is asymptotic for the longline survey and fishery and dome-shaped for the trawl fishery. Selection of younger fish during short open-access seasons likely was due to crowding of the fishing grounds, so that some fishermen were pushed to fish shallower water that young fish inhabit (Sigler and Lunsford 2001). Young fish are more vulnerable and older fish are less vulnerable to the trawl fishery (see following figure [only 1996 data shown for brevity]) because trawling often occurs on the continental shelf and < 300 m water of the continental slope that young sablefish inhabit.



Catch rate data are available from 1990-2003. Catchability was separately estimated for the "derby" (through 1994) and IFQ (1995 and later) fisheries. On average, fishery catchability is 1.8 times greater during the IFQ fishery, the same as estimated in an independent analysis of the effects of individual quotas on catching efficiency in the fishery (Sigler and Lunsford 2001). Like the selectivity effect, lower catching efficiency during the “derby” fishery likely occurred due to crowding of the fishing grounds, so that fishermen were pushed to fish areas where sablefish densities were less. Fishermen also fished the same area repeatedly, with associated decreases in catch rates due to “fishing down” the area.

Fishery catch rates often are biased estimates of relative abundance (e.g. Crecco and Overholtz 1990). We examined possible biases in US fishery catch rate data; see section 3.1.2. We also tested the effect of including fishery catch rates in the assessment model. Both Japan and US fishery catch rate data are used in the assessment model. However we only tested the effect of US fishery catch rate data because there was no alternative abundance index during most years of the Japanese longline fishery, unlike the US fishery, which overlaps the longline surveys. Including US fishery catch rates has little effect on spawning biomass estimates, increasing spawning biomass estimates <1% for 1990-2003, the years of US fishery catch rate data.

3.5 Projections and harvest alternatives

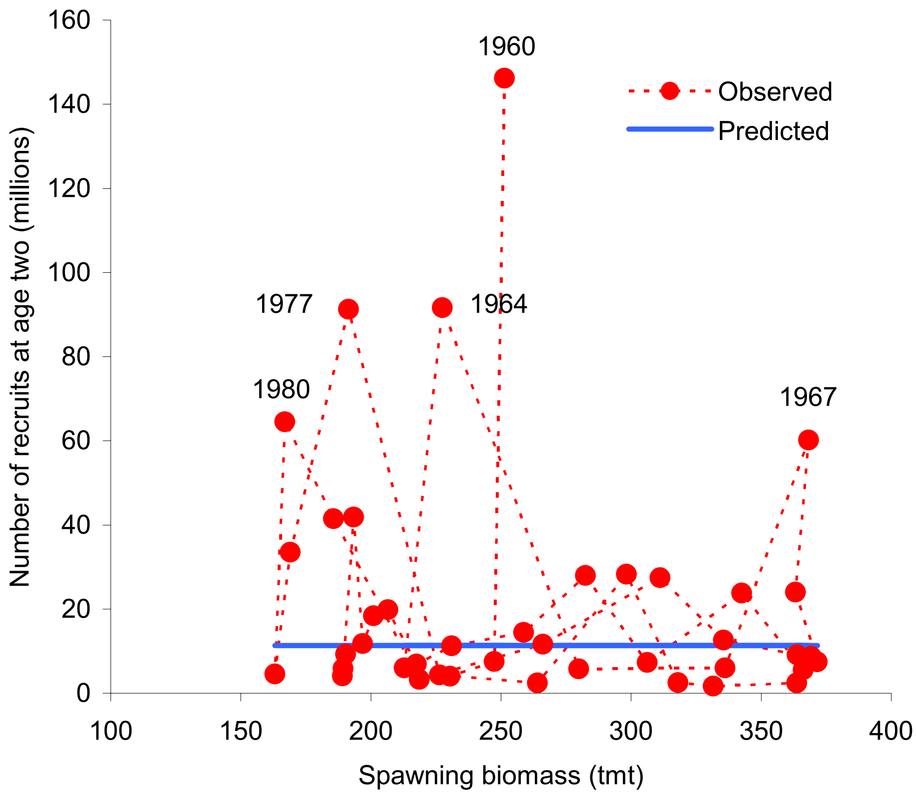
Reference fishing mortality rates

Reference point values, $B_{40\%}$, $F_{40\%}$, $F_{35\%}$, and adjusted $F_{40\%}$ and $F_{35\%}$ based on projected 2005 spawning biomass, are shown in the summary table, section 3.7. Reference biomass values always were computed using the average recruitment from the 1977-2000 year classes. Projected 2005 spawning biomass is 37% of unfished spawning biomass and 92% of $B_{40\%}$. A downward adjustment to the reference fishing mortality rates is required to set the maximum Acceptable Biological Catch under Tier 3b. Reference point values for fishing mortality are less than recent assessments. For example, $F_{40\%}$ is 0.112 for the 2004 assessment, 0.131 for the 2003 assessment and 0.133 for both the 2001 and 2002 assessments.

Reference fishing values are less for the 2004 assessment because natural mortality is lower and fishery selectivity is earlier compared to recent assessments. For example, natural mortality is 0.10 for the 2004 assessment compared to 0.107 for the 2003 assessment; the age at 50% selection for the longline fishery is 4.6 years for the 2004 assessment compared to 5.2 years for the 2003 assessment.

Maximum sustainable yield

We fit a Beverton-Holt curve assuming a log-normal distribution for recruitment. The predicted values are plotted only for the observed range of spawning biomass because the shape of the relationship below the historic low biomass is unknown.



Population projections

A standard set of projections is required for each stock managed under Tiers 1, 2, or 3 of Amendment 56. This set of projections encompasses seven harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Policy Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

For each scenario, the projections begin with the vector of 2004 numbers at age as estimated in the assessment. This vector is then projected forward to the beginning of 2005 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2004. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1,000 times to obtain distributions of possible future stock sizes, fishing mortality rates, and catches.

Five of the seven standard scenarios will be used in an Environmental Assessment prepared in conjunction with the final SAFE. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2005, are as follow ("*max* F_{ABC}" refers to the maximum permissible value of F_{ABC} under Amendment 56):

> *Scenario 1*: In all future years, F is set equal to *max* F_{ABC}. (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TACs.)
>
> *Scenario 2*: In all future years, F is set equal to a constant fraction of *max* F_{ABC}, where this fraction is equal to the ratio of the F_{ABC} value for 2005 recommended in the assessment to the *max* F_{ABC} for 2003. (Rationale: When F_{ABC} is set at a value below *max* F_{ABC}, it is often set at the value recommended in the stock assessment.)
>
> *Scenario 3*: In all future years, F is set equal to 50% of max F_{ABC}. (Rationale: This scenario provides a likely lower bound on F_{ABC} that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)
>
> *Scenario 4*: In all future years, F is set equal to the 2000-2004 average F. (Rationale: For some stocks, TAC can be well below ABC, and recent average F may provide a better indicator of F_{TAC} than F_{ABC}.)
>
> *Scenario 5*: In all future years, F is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether a stock is currently in an overfished condition or is approaching an overfished condition. These two scenarios are as follow (for Tier 3 stocks, the MSY level is defined as $B_{35\%}$):

> *Scenario 6*: In all future years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be above ½ of its MSY level in 2005 and above its MSY level in 2015 under this scenario, then the stock is not overfished.)
>
> *Scenario 7*: In 2005 and 2006, F is set equal to *max* F_{ABC}, and in all subsequent years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is expected to be above its MSY level in 2017 under this scenario, then the stock is not approaching an overfished condition.)

The projected 2005 exploitable biomass under the author recommended harvest policy is 232,000 mt for Aleutian Islands, eastern Bering Sea, Gulf of Alaska combined, spawning (male and female) biomass 204,000 mt (Table 3.9). Spawning biomass currently equals 37% of the unfished value. Spawning biomass is projected to fall to 36% of the unfished level in 2006 and 35% in 2008 (Figure 3.10). Abundance is projected to fall because year classes following the strong 1997 year class are weaker than the 1997 year class. The 1998 year class is not above average as originally thought (the current estimate is 14.3 million). The 2000 year class may be above average (the current estimate is 30.9 million), but more years of data are needed to confirm the estimate.

Spawning biomass, fishing mortality, and yield are tabulated for the seven standard projection scenarios (Table 3.10).

Status determination

Alaska sablefish are not overfished nor are they approaching an overfished condition (Table 3.10).

Bayesian analysis

The estimates of ending spawning biomass are well-defined by the available data. Most of the probability lies between 185,000 and 235,000 mt (Figure 3.13). The probability changes smoothly and is well-mapped.

Scatter plots of selected model parameters were plotted pair-wise to evaluate the shape of the posterior distribution (Figure 3.14). The plots indicate that the parameters are reasonably well-defined by the data.

Decision analysis

The maximum permissible 2005 catch is 21,000 mt falling to 18,500 mt in 2007 (Table 3.10). The choice of threshold affects the determination of which ABC leaves enough spawning biomass for successive generations to replace or surpass each other on average. A threshold of $B_{18\%}$ was estimated for sablefish; a default threshold of $B_{30\%}$ is recommended when there is no other basis for estimating the threshold level (section 3.2). Spawning biomass was compared to threshold biomass for each MCMC run and the probability that spawning biomass falls below threshold biomass was estimated (Figure 3.15a). During the next three years, the probability of falling below $B_{18\%}$ is nil, the probability of falling below $B_{30\%}$ is 0.06, and the probability of falling below $B_{35\%}$ is 0.44 (Figure 3.15b).

Acceptable biological catch

We recommend a 2005 ABC of 21,000 mt. The maximum permissible yield for 2005 from an adjusted $F_{40\%}$ strategy is 21,000 mt. The maximum permissible yield for 2005 represents a decrease (9%) from the 2004 ABC of 23,000 mt and is similar to the 2003 ABC of 20,900 mt. Abundance is projected to decrease in 2005 (2%).

Spawning biomass currently is at 37% of the unfished level, but is projected to fall to 35% of the unfished level in 2007 for maximum permissible fishing mortality. Abundance is projected to fall because year classes following the strong 1997 year class are weaker than the 1997 year class. The maximum permissible ABC also is projected to decline to 19,900 mt in 2006 and 18,500 mt in 2007.

During the next three years, the probability of spawning biomass falling below the estimated threshold of $B_{18\%}$ and the NMFS definition of MSST for a Tier 3 stock of $B_{17.5\%}$ is nil. The probability of falling below the threshold when resiliency is unknown of $B_{30\%}$ (Mace 1994) in three years is small (0.06). Thus the risk that maximum permissible yield will reduce spawning biomass below the replacement level is low. The long-term probability depends on future recruitment, but will be updated each year as new data becomes available.

Table.–Maximum permissible ABC (Tier 3, $F_{40\%}$ adjusted value) and ABCs recommended by the stock assessment authors, Plan Teams, SSC, and NPFMC, by fishing year 1997-2004.

Year	Maximum permissible	Authors	Plan Teams	SSC	NPFMC
1997	23,200	17,200	19,600	17,200	17,200
1998	19,000	16,800	16,800	16,800	16,800
1999	15,900	15,900	15,900	15,900	15,900
2000	17,300	17,000	17,300	17,300	17,300
2001	16,900	16,900	16,900	16,900	16,900
2002	21,300	17,300	17,300	17,300	17,300
2003	25,400	18,400	18,400	20,900	20,900
2004	25,400	23,000 or 20,700	23,000	23,000	23,000

Area allocation of harvests

The combined ABC has been apportioned to regions using weighted moving average methods since 1993; these methods reduce the magnitude of inter-annual changes in the allocation. Weighted moving average methods are robust to uncertainties about movement rates and measurement error of biomass distribution, while adapting to current information about biomass distribution. The 1993 TAC was apportioned using a 5 year running average with emphasis doubled for the current year survey abundance index in weight (relative population weight or RPW). Since 1995, the ABC was allocated using an exponential weighting of regional RPW's. Exponential weighting is implied under certain conditions by the Kalman filter. The exponential factor is the measurement error variance divided by the prediction error variance (Meinhold and Singpurwalla 1983). Prediction error variance depends on the variances of the previous year's estimate, the process error, and the measurement error. When the ratio of measurement error variance to process error variance is r, the exponential factor is equal to $1-2/(\sqrt{4r+1}+1)$ (Thompson 2004). For sablefish we don't actually estimate these values but just use the exponential weighting with the exponential factor set at ½, so that the weight of each year's value is ½ the weight of the following year. The weights are year index 5: 0.0625; 4: 0.0625; 3: 0.1250; 2: 0.2500; 1: 0.5000. A $(1/2)^x$ weighting scheme reduced annual fluctuations in ABC, while keeping regional fishing rates from exceeding overfishing levels in a stochastic migratory model, where *x* is the year index (J. Heifetz, Auke Bay Lab, pers. comm.). Notably, mixing rates for sablefish are sufficiently high and fishing rates sufficiently low that moderate variations of biomass based apportionment would not significantly change overall sablefish yield unless there are strong differences in recruitment, growth, and survival by area (Heifetz et al. 1997).

Previously, the Council approved allocations of the ABC based on survey data alone. Starting with the 2000 ABC, the Council approved an allocation based on survey and fishery data. We also used survey and fishery data to allocate the 2005 ABC. The fishery and survey information were combined to allocate ABC using the following method. The RPW based on the fishery data were weighted with the same exponential weights used to weight the survey data (year index 5: 0.0625; 4: 0.0625; 3: 0.1250; 2: 0.2500; 1: 0.5000). The fishery and survey data were combined by computing a weighted average of the survey and fishery estimates, with the weight inversely proportional to the variability of each data source. The variance for the fishery data is about twice that for the survey data, so the survey data was weighted twice as much as the fishery data.

Apportionments are	2004	2004	2003	2005	2004	Authors	Change

based on survey and fishery information	ABC Percent	Survey RPW	Fishery RPW	ABC Percent	ABC	2005 ABC	
Total					23,010	**21,000**	-9%
Bering Sea	13%	14%	3%	12%	3,010	**2,440**	-19%
Aleutians	15%	12%	6%	12%	3,450	**2,620**	-24%
Gulf of Alaska	72%	75%	90%	76%	16,550	**15,940**	-4%
Western	18%	14%	11%	16%	2,930	**2,540**	-13%
Central	44%	51%	40%	45%	7,300	**7,250**	-1%
W. Yakutat	14%	14%	18%	15%	2,350	**2,390**	2%
E. Yakutat / Southeast	24%	20%	31%	24%	3,970	**3,760**	-5%

The survey percentages indicate more fish in the Western and Central Gulf of Alaska and fewer fish in the eastern Gulf of Alaska than the fishery percentages. This occurs because survey catch rates are higher than fishery catch rates in the Western and Central Gulf of Alaska and lower than fishery catch rates in the eastern Gulf of Alaska (Figure 3.4).

Regional estimates of age-4+ biomass are tabulated in Table 3.11.

Overfishing level

Applying an adjusted $F_{35\%}$ as prescribed for Over Fishing Level (OFL) in Tier 3b results in a value of 25,400 mt for the combined stock. The OFL is apportioned by region, Bering Sea (2,950 mt), Aleutian Islands (3,170 mt), and Gulf of Alaska (19,280 mt), by the same method as the ABC apportionment.

3.6 Ecosystem considerations

Ecosystem considerations for the Alaska sablefish fishery are summarized in Table 3.12.

3.6.1 Ecosystem effects on the stock

1) Prey population trends: Young-of-the-year sablefish prey mostly on euphausiids; juvenile and adult sablefish are opportunistic feeders. Larval sablefish abundance has been linked to copepod abundance (McFarlane and Beamish 1992). Young-of-the-year abundance may be similarly affected by euphausiid abundance because of their apparent dependence on a single species. Juvenile and adult sablefish unlikely are affected by availability and abundance of individual prey species because they are opportunistic feeders. The only likely way prey trends likely affect growth or survival of juvenile and adult sablefish is by overall changes in ecosystem productivity. The dependence of larval and young-of-the-year sablefish on single prey species may be the cause of observed wide variation in annual sablefish recruitment. No time series of information is available on copepod and euphausiid abundance to predict sablefish abundance based on this predator-prey relationship.

Young-of-the-year sablefish diet was mostly euphausiids (Sigler et al. 2001). For juvenile and adult sablefish, sablefish < 60 cm FL consumed more euphausiids, shrimp, and cephalopods and sablefish > 60 cm FL consumed more fish (Yang and Nelson 2000). Juvenile and adult sablefish are opportunistic feeders. Fish constituted 3/4 of stomach content weight, with the remainder invertebrates, in the Gulf of Alaska sablefish diet study (Yang and Nelson 2000). Pollock were the most important fish; eulachon, capelin, Pacific herring, Pacific cod, Pacific sand lance, and some flatfish also were found. Squid were the most important invertebrate and euphausiids and jellyfish both also were found. Fish made up 76 percent of the diet in feeding studies conducted off Oregon and California (Laidig et al 1997). Euphausiids dominated the diet off the southwest coast of Vancouver Island; herring and other fish were increasingly important with sablefish size (Tanasichuk 1997).

2) Predator population trends: The main sablefish predators are adult coho and chinook salmon, which

prey on young-of-the-year sablefish. Salmon abundance has decreased in recent years, likely reducing stock mortality rates over time.

Adult coho and chinook salmon prey on young-of-the-year sablefish, which were the fourth most commonly reported species from the salmon troll logbook program from 1977 to 1984 (Wing 1985). The only other fish species reported to prey on sablefish in the Gulf of Alaska is Pacific halibut; sablefish comprised less than 1% of their stomach contents (M-S. Yang, Alaska Fisheries Science Center, 14 October 1999). Fish are an important part of sperm whale diet in some parts of the world, including the northeastern Pacific Ocean (Kawakami 1980). Cephalopods were important in the western Aleutians and Bering Sea but fish became more important in the eastern Aleutians and Gulf of Alaska. The fish species was not identified in the Alaska sperm whale diets, but sablefish were found in 8.3% of sperm whale stomachs off California.

3) Habitat quality: Water mass movements and temperature appear related to recruitment success (Sigler et al. 2001). Above-average recruitment was somewhat more likely with northerly winter currents and much less likely for years when the drift was southerly. Recruitment was above average in 61% of the years when temperature was above average, but was above average in only 25% of the years when temperature was below average. Growth rate of young-of-the-year sablefish is higher in years when they are more abundant.

3.6.2 Fishery effects on the ecosystem

1) Fishery-specific contribution to bycatch of prohibited species, forage species, HAPC biota, marine mammals and birds, and other sensitive non-target species such as sharks are tabulated on the next page. Sablefish fishery catches significant portions of the spiny dogfish and unidentified shark total catch. The trend is variable. Sablefish fishery catches the majority of grenadier total catch (average 71%). The trend is stable. Seabirds may be captured by longlines. Sablefish fishery catch of seabirds averages 10% of the total catch. The trend is variable but appears to be decreasing, presumably due to widespread use of measures to reduce seabird catch. Sablefish fishery catches of the remaining species is minor.

The fishing effects of the current fishery management regime are either minimal or temporary based on the criteria that sablefish currently are above MSST (Draft EFH SEIS). However caution is warranted. Sablefish are substantially dependent on benthic prey (18% of diet by weight) which may be adversely affected by fishing. Little is known about sablefish spawning habitat and effects of fishing on that habitat. Habitat requirements for growth to maturity are better known, but this knowledge is incomplete. Although sablefish do not appear substantially dependent on physical structure, living structure and coral are substantially reduced in much of the area where sablefish are concentrated. Living structure is reduced 6-15% and hard coral is reduced 29-55% in three areas comprising 87% of the habitat where sablefish are concentrated (Aleutian Islands deep [6% of sablefish habitat], Gulf of Deep Shelf [41%] and Gulf of Alaska slope [41%]). Other anthropogenic effects besides fishing, such as coastal development, may impact juvenile sablefish habitat. Other fishing effects not mediated by habitat (fishing on the continental shelf, catching juvenile sablefish as bycatch) may reduce juvenile survivorship and are a particular concern in areas of the Bering Sea and Gulf of Alaska where juvenile sablefish are concentrated and bottom trawl fishing intensity is high.

The shift from an open-access to an IFQ fishery has increased catching efficiency 1.8 times, thereby reducing the number of hooks deployed (Sigler and Lunsford 2001). Although the effects of longline gear on bottom habitat are poorly known, to whatever unknown extent the habitat is affected, the reduced number of hooks deployed during the IFQ fishery reduces these habitat effects. The IFQ fishery likely has also reduced discards of other species because of the slower pace of the fishery and the incentive to maximize value from the catch.

Table.—Catch (percent and for average, mt) of prohibited species, forage species, HAPC biota, marine mammals and birds, and other sensitive non-target species such as sharks in sablefish directed fisheries.

Species	1997	1998	1999	2000	2001	2002	Average catch (%)	Average catch (mt)
sculpin	0%	0%	0%	0%	0%	0%	0%	10
skates	2%	12%	2%	2%	2%	2%	4%	863
shark	26%	88%	4%	18%	43%	24%	66%	246
salmonshk	0%	0%	11%	1%	0%	1%	3%	3
dogfish	20%	7%	26%	34%	24%	59%	21%	102
sleepershk	12%	3%	3%	15%	3%	1%	6%	48
octopus	5%	0%	0%	0%	1%	1%	1%	6
squid	0%	0%	0%	0%	0%	0%	0%	1
smelts	0%	0%	0%	0%	0%	0%	0%	-
gunnel	0%	0%	0%	0%	0%	0%	0%	-
sticheidae	0%	0%	0%	0%	2%	0%	1%	0
sandfish	0%	0%	0%	0%	0%	0%	0%	-
lanternfish	0%	0%	0%	0%	0%	0%	0%	-
sandlance	0%	0%	0%	0%	0%	0%	0%	-
grenadier	73%	70%	66%	72%	80%	69%	71%	12,930
otherfish	1%	81%	3%	11%	5%	2%	38%	1,401
crabs	0%	0%	0%	0%	0%	0%	0%	0
starfish	0%	17%	0%	0%	0%	0%	2%	128
jellyfish	0%	0%	0%	0%	0%	0%	0%	0
invertunid	0%	0%	0%	0%	0%	0%	0%	0
seapen/whip	6%	0%	0%	2%	1%	0%	1%	0
sponge	0%	0%	0%	0%	0%	0%	0%	0
anemone	0%	0%	1%	0%	1%	1%	0%	1
tunicate	0%	0%	0%	0%	0%	0%	0%	0
benthinv	0%	0%	0%	0%	0%	1%	0%	1
snails					0%	0%	0%	-
echinoderm	0%	0%	0%	1%	1%	0%	1%	0
coral	0%	2%	1%	4%	0%	2%	1%	1
shrimp	0%	0%	0%	0%	1%	0%	0%	0
birds	7%	10%	21%	10%	13%	5%	11%	3

2) Fishery-specific concentration of target catch in space and time relative to predator needs in space and time (if known) and relative to spawning components: The sablefish fishery largely is dispersed in space and time. The longline fishery lasts 8-1/2 months. The quota is allocated among six regions of Alaska.

3) Fishery-specific effects on amount of large size target fish: The longline fishery catches mostly medium and large-size fish which are typically mature. The trawl fishery, which accounts for about 12% of the total catch, often catches small and medium fish. The trawl fishery typically occurs on the continental shelf which juvenile sablefish inhabit. Catching these fish as juveniles reduces the yield available from each recruit.

4) Fishery-specific contribution to discards and offal production: Discards of sablefish in the longline fishery are small, typically less than 5% of total catch (Table 3.2). The catch of sablefish in the longline fishery typically consists of a high proportion of sablefish, 90% and more. However at times grenadiers may be an significant catch and they are discarded.

5) Fishery-specific effects on age-at-maturity and fecundity of the target species: The shift from an open-

access to an IFQ fishery has decreased harvest of immature fish and improved the chance that individual fish will reproduce at least once. Spawning potential of sablefish, expressed as spawning biomass per recruit, increased 9% for the IFQ fishery (Sigler and Lunsford 2000).

The longline fishery catches mostly medium and large-size fish which are typically mature. The trawl fishery, which accounts for about 12% of the total catch, often catches small and medium fish. The trawl fishery typically occurs on the continental shelf which juvenile sablefish inhabit. Catching these fish as juveniles reduces the yield available from each recruit, though the shift likely is small because trawl fishery catches currently make up only a small part of the total sablefish caught.

6) Fishery-specific effects on EFH non-living substrate: See item 1.

3.6.3 Data gaps and research priorities

Data gaps which prevent assessing certain effects: No time series of information is available on copepod and euphausiid abundance to predict sablefish abundance based on this predator-prey relationship. Need better identification of shark species, which are easy to differentiate. Need improved coverage of trawl vessels catching sablefish, both to verify discard rates and to obtain the size of fish discarded. Not enough size information has been collected in recent years for the length data from the trawl fisheries to be usable.

3.7 Summary

The following table summarizes key results from the assessment of sablefish in Alaska:

Age at 50% selection for survey	4.0
Age at 50% selection for "derby" fishery	3.9
Age at 50% selection for IFQ fishery	4.6
Age at 50% selection for trawl fishery	2.8
Natural mortality (M)	0. 10
Tier	3b
Equilibrium unfished spawning biomass	556
Reference point spawning biomass, $B_{40\%}$	223
Reference point spawning biomass, $B_{35\%}$	195
2005 exploitable biomass	232
2005 spawning biomass	204
2005 total (age-4+) biomass	253
Maximum permissible fishing level	
$F_{40\%}$	0.112
2005 $F_{40\%}$ adjusted	0.102
2005 $F_{40\%}$ adjusted Yield	21.0
Overfishing level	
$F_{35\%}$	0.136
2005 $F_{35\%}$ adjusted	0.124
2005 $F_{35\%}$ adjusted Yield	25.4
Authors' recommendation	
2005 F	0.102
2005 ABC	21.0

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Tables

Table 3.1--Alaska sablefish catch (mt). The values include landed catch and discard estimates. Discards were estimated for U.S. fisheries before 1993 by multiplying reported catch by 2.9% for fixed gear and 26.9% for trawl gear (1994-1997 averages) because discard estimates were unavailable. Eastern includes both West Yakutat and East Yakutat / Southeast.

		BY AREA								BY GEAR	
Year	Grand total	Bering Sea	Aleu-tians	Western	Central	Eastern	West Yakutat	East Yakutat/ Soeast.	Un-known	Fixed	Trawl
1956	773	0	0	0	0	773			0	773	0
1957	2,059	0	0	0	0	2,059			0	2,059	0
1958	477	6	0	0	0	471			0	477	0
1959	910	289	0	0	0	621			0	910	0
1960	3,054	1,861	0	0	0	1,193			0	3,054	0
1961	16,078	15,627	0	0	0	451			0	16,078	0
1962	26,379	25,989	0	0	0	390			0	26,379	0
1963	16,901	13,706	664	266	1,324	941			0	10,557	6,344
1964	7,273	3,545	1,541	92	955	1,140			0	3,316	3,957
1965	8,733	4,838	1,249	764	1,449	433			0	925	7,808
1966	15,583	9,505	1,341	1,093	2,632	1,012			0	3,760	11,823
1967	19,196	11,698	1,652	523	1,955	3,368			0	3,852	15,344
1968	30,940	14,374	1,673	297	1,658	12,938			0	11,182	19,758
1969	36,831	16,009	1,673	836	4,214	14,099			0	15,439	21,392
1970	37,858	11,737	1,248	1,566	6,703	16,604			0	22,729	15,129
1971	43,468	15,106	2,936	2,047	6,996	16,382			0	22,905	20,563
1972	53,080	12,758	3,531	3,857	11,599	21,320			15	28,538	24,542
1973	36,926	5,957	2,902	3,962	9,629	14,439			37	23,211	13,715
1974	34,545	4,258	2,477	4,207	7,590	16,006			7	25,466	9,079
1975	29,979	2,766	1,747	4,240	6,566	14,659			1	23,333	6,646
1976	31,684	2,923	1,659	4,837	6,479	15,782			4	25,397	6,287
1977	21,404	2,718	1,897	2,968	4,270	9,543			8	18,859	2,545
1978	10,394	1,193	821	1,419	3,090	3,870			1	9,158	1,236
1979	11,814	1,376	782	999	3,189	5,391			76	10,350	1,463
1980	10,444	2,205	275	1,450	3,027	3,461			26	8,396	2,048
1981	12,604	2,605	533	1,595	3,425	4,425			22	10,994	1,610
1982	12,048	3,238	964	1,489	2,885	3,457			15	10,204	1,844
1983	11,715	2,712	684	1,496	2,970	3,818			35	10,155	1,560
1984	14,109	3,336	1,061	1,326	3,463	4,618			305	10,292	3,817
1985	14,465	2,454	1,551	2,152	4,209	4,098			0	13,007	1,457
1986	28,892	4,184	3,285	4,067	9,105	8,175			75	21,576	7,316
1987	35,163	4,904	4,112	4,141	11,505	10,500			2	27,595	7,568
1988	38,406	4,006	3,616	3,789	14,505	12,473			18	29,282	9,124
1989	34,829	1,516	3,704	4,533	13,224	11,852			0	27,509	7,320
1990	32,115	2,606	2,412	2,251	13,786	11,030			30	26,598	5,518
1991	27,073	1,318	2,168	1,821	11,662	10,014			89	23,124	3,950
1992	24,932	586	1,497	2,401	11,135	9,171			142	21,614	3,318
1993	25,433	668	2,080	739	11,971	9,975	4,619	5,356	0	22,912	2,521
1994	23,760	694	1,726	555	9,495	11,290	4,497	6,793	0	20,797	2,963
1995	20,954	990	1,333	1,747	7,673	9,211	3,866	5,345	0	18,342	2,612
1996	17,577	697	905	1,648	6,772	7,555	2,899	4,656	0	15,390	2,187
1997	14,922	728	929	1,374	6,237	5,653	1,928	3,725	0	13,287	1,635
1998	14,108	614	734	1,435	5,877	5,448	1,969	3,479	0	12,644	1,464
1999	13,575	677	671	1,487	5,873	4,867	1,709	3,158	0	11,590	1,985
2000	15,919	828	1,314	1,587	6,172	6,018	2,066	3,952	0	13,906	2,013
2001	14,097	878	1,092	1,589	5,518	5,020	1,737	3,283	0	10,863	1,783
2002	14,789	1,166	1,139	1,863	6,180	4,441	1,550	2,891	0	10,852	2,261
2003	16,432	1,006	1,081	2,110	7,090	5,145	1,822	3,323	0	14,370	2,062

Table 3.2--Discarded catches of sablefish (amount [mt] and percent of total catch) by target fishery, gear (H&L=hook & line, TWL=trawl), and management area.

		Eastern Bering Sea		**Aleutian Islands**		**Western**		**Central**		**West Yakutat**		**East Yakutat/ Southeast**	
Target fishery	Year	Amt.	Pct.	Amt.	Pct.	Amt.	Pct.	Amt.	Pct.	Amt.	Pct.	Amt.	Pct.
Sablefish (H&L)	1994	7	4	16	1	11	2	75	1	39	1	66	1
	1995	5	1	8	1	40	2	111	2	71	2	132	2
	1996	7	2	9	1	33	2	137	3	56	2	79	2
	1997	8	4	19	3	41	3	116	2	88	5	123	3
	1998	6	4	5	1	91	6	210	5	46	2	184	5
	1999	2	1	34	6	38	3	124	3	27	2	68	2
	2000	2	1	7	1	49	4	168	4	46	2	159	3
	2001	9	5	16	2	34	2	133	3	33	2	1153	2
	2002	5	2	5	2	32	2	109	3	33	2	79	3
Greenland	1994	1	1	2	3	0	-	0	-	0	-	0	-
turbot (H&L)	1995	82	48	40	53	0	-	0	-	0	-	0	-
	1996	75	41	5	17	0	-	0	-	0	-	0	-
	1997	92	40	1	11	0	-	0	-	0	-	0	-
	1998	85	31	7	5	0	-	0	-	0	-	0	-
	1999	45	24	13	19	0	-	0	-	0	-	0	-
	2000	27	15	15	14	0	-	0	-	0	-	0	-
	2001	36	25	0	1	0	-	0	-	0	-	0	-
	2002	84	67	0	2	0	-	0	-	0	-	0	-
Pacific cod (H&L)	1994	7	15	1	2	1	23	0	-	0	-	0	-
	1995	15	37	2	18	2	96	4	11	0	-	0	-
	1996	15	64	13	19	0	-	0	-	0	-	0	-
	1997	15	71	5	16	8	75	114	89	0	-	0	-
	1998	9	63	4	31	0	-	5	46	0	2	0	-
	1999	9	61	2	12	0	-	1	6	0	-	0	-
	2000	54	79	3	15	0	23	34	81	0	-	1	100
	2001	34	57	9	23	1	9	7	27	0	-	0	5
	2002	36	61	2	3	20	81	12	44	0	-	0	-
All other (H&L)	1994	0	0	0	0	0	-	0	-	4	72	0	-
	1995	0	0	3	83	0	-	0	-	0	-	0	7
	1996	0	57	0	6	0	-	0	-	0	-	0	-
	1997	1	39	0	-	0	-	0	-	0	-	0	-
	1998	2	90	0	-	0	-	3	36	0	5	6	48
	1999	0	5	0	0	0	4	1	61	1	26	6	48
	2000	1	100	0	2	0	-	0	5	0	-	0	-
	2001	0	42	0	10	0	100	2	28	1	49	90	38
	2002	0	29	0	2	0	27	2	18	10	98	11	49
Total H&L	1994	14	5	19	1	11	3	75	1	44	1	66	1
	1995	102	16	52	5	42	3	115	2	71	2	132	2
	1996	98	19	27	4	33	2	137	3	56	2	79	2
	1997	117	24	25	3	49	4	230	5	88	5	123	3
	1998	101	22	16	3	91	6	218	5	46	2	190	5
	1999	57	15	48	7	38	3	126	3	28	2	74	2
	2000	83	20	26	3	49	4	213	4	52	2	240	4
	2001	80	20	25	3	35	2	142	3	34	2	1243	2
	2002	125	27	27	3	52	3	123	3	43	3	91	3

Table 3.2 cont.

		Eastern Bering Sea		Aleutian Islands		Western		Central		West Yakutat		East Yakutat/ SEO	
Target fishery	Year	Amt.	Pct.	Amt.	Pct.	Amt.	Pct.	Amt.	Pct.	Amt.	Pct.	Amt.	Pct.
Sablefish (TWL)	1994	13	28	0	-	0	-	10	15	0	-	0	-
	1995	0	-	1	10	0	-	62	61	0	-	0	-
	1996	0	1	0	-	0	-	1	2	2	3	0	-
	1997	0	-	0	-	0	-	0	-	0	-	0	-
	1998	0	-	0	-	0	-	0	-	0	-	0	-
	1999	0	-	0	-	0	-	0	-	0	-	0	-
	2000	0	-	0	-	0	2	0	-	0	-	0	-
	2001	0	-	0	-	0	-	0	-	0	-	0	-
	2002	0	-	0	-	0	-	0	-	17	23	0	-
Rockfish (TWL)	1994	1	-	9	12	1	1	54	8	28	13	0	-
	1995	0	-	1	4	2	4	167	21	57	25	0	-
	1996	0	5	0	2	0	-	208	19	28	13	0	-
	1997	0	-	1	5	0	5	159	19	5	13	0	-
	1998	0	-	0	1	0	-	67	9	0	-	0	-
	1999	0	-	0	-	1	1	250	30	2	1	0	-
	2000	0	-	0	-	1	2	155	18	1	1	0	-
	2001	0	-	1	3	0	-	191	25	30	0	0	-
	2002	0	4	0	1	24	25	433	36	2	3	0	-
Arrowtooth (TWL)	1994	0	-	0	-	0	-	20	42	0	-	0	-
	1995	0	-	0	-	0	-	286	75	0	-	0	-
	1996	0	-	0	-	1	36	133	76	0	-	0	-
	1997	0	-	0	-	0	-	24	47	0	-	0	-
	1998	5	21	0	-	13	62	62	96	0	-	0	-
	1999	6	13	0	-	32	78	53	81	0	-	0	-
	2000	4	5	0	-	60	48	115	64	0	-	0	-
	2001	10	13	0	-	7	93	7	93	0	-	0	-
	2002	18	19	0	-	69	63	55	57	0	-	0	-
Deepwater flatfish (TWL)	1994	0	-	0	-	0	-	180	40	12	26	47	73
	1995	0	-	0	-	0	-	76	41	7	22	0	-
	1996	0	-	0	-	0	-	66	39	6	23	0	-
	1997	0	-	0	-	0	-	117	47	3	49	93	59
	1998	0	-	0	-	0	-	71	35	1	29	0	-
	1999	0	-	0	-	0	-	130	65	33	61	0	-
	2000	0	-	0	-	0	-	3	13	0	4	0	-
	2001	0	-	0	-	17	41	17	41	4	32	0	-
	2002	0	-	0	-	0	-	18	57	0	-	0	-
Shallow water flatfish (TWL)	1994	0	-	0	-	0	-	9	8	0	-	0	-
	1995	0	-	0	-	0	-	18	33	0	-	0	-
	1996	0	-	0	-	0	-	7	23	0	-	0	-
	1997	0	-	0	-	0	-	11	32	0	-	0	-
	1998	0	-	0	-	0	-	32	84	0	-	0	-
	1999	0	-	0	-	0	-	0	-	0	-	0	-
	2000	0	-	0	-	0	-	34	67	2	100	0	-
	2001	0	-	0	-	34	86	34	86	0	-	0	-
	2002	0	-	0	-	0	-	8	54	0	-	0	-

Table 3.2 cont.

		Eastern Bering Sea		Aleutian Islands		Western		Central		West Yakutat		East Yakutat/ SEO	
Target fishery	Year	Amt.	Pct.	Amt.	Pct.	Amt.	Pct.	Amt.	Pct.	Amt.	Pct.	Amt.	Pct.
Rex sole (TWL)	1994	0	-	0	-	0	-	137	30	0	-	0	-
	1995	0	-	0	-	0	-	36	16	6	94	0	-
	1996	0	-	0	-	0	-	32	24	42	-	0	-
	1997	0	-	0	-	0	3	5	13	16	77	0	-
	1998	0	-	0	-	3	34	6	11	0	-	0	-
	1999	0	-	0	-	32	64	18	24	0	-	0	-
	2000	0	-	0	-	40	58	82	62	0	-	0	-
	2001	0	-	0	-	119	73	119	73	0	-	0	-
	2002	0	-	0	-	58	32	58	32	0	-	0	-
Greenland turbot (TWL)	1994	35	12	10	18	0	-	0	-	0	-	0	-
	1995	7	3	16	22	0	-	0	-	0	-	0	-
	1996	3	6	0	-	0	-	0	-	0	-	0	-
	1997	0	1	0	-	0	-	0	-	0	-	0	-
	1998	1	1	0	-	0	-	0	-	0	-	0	-
	1999	6	5	0	-	0	-	0	-	0	-	0	-
	2000	0	-	0	-	0	-	0	-	0	-	0	-
	2001	0	-	0	-	0	-	0	-	0	-	0	-
	2002	2	5	0	-	0	-	0	-	0	-	0	-
All other (TWL)	1994	17	48	0	4	3	54	35	25	0	-	0	-
	1995	13	61	3	49	8	70	18	20	0	-	0	-
	1996	16	26	10	77	2	13	1	13	0	-	0	-
	1997	11	37	0	23	1	15	44	48	0	-	0	-
	1998	7	11	4	43	4	62	56	54	1	39	0	-
	1999	37	29	0	-	39	99	122	86	0	-	0	-
	2000	48	37	0	23	11	98	108	75	0	-	0	-
	2001	16	10	1	100	37	53	37	53	0	-	0	-
	2002	30	21	1	9	1	4	1	4	0	-	0	-
Total TWL	1994	66	17	18	12	4	4	445	23	40	15	47	63
	1995	20	7	20	19	10	13	663	36	70	26	0	-
	1996	19	14	10	41	3	11	448	27	77	22	0	-
	1997	11	20	1	6	2	8	360	28	23	35	93	55
	1998	12	9	4	21	20	44	294	24	2	3	0	-
	1999	48	17	0	-	103	59	572	43	35	18	0	-
	2000	54	19	0	-	112	45	496	36	3	4	0	-
	2001	26	7	2	4	405	37	405	37	4	2	0	-
	2002	51	17	1	2	575	37	575	37	19	15	0	-
Grand total	1994	80	12	38	2	15	3	520	6	83	2	112	2
	1995	122	13	72	7	53	3	777	10	141	4	132	2
	1996	117	18	36	5	35	2	585	9	133	5	79	2
	1997	128	23	26	3	51	4	589	9	111	6	216	6
	1998	114	19	20	3	111	8	512	9	48	2	190	5
	1999	109	16	49	7	141	9	703	12	63	4	74	2
	2000	138	19	26	3	161	10	709	11	55	3	240	4
	2001	106	14	27	3	116	7	547	10	38	2	66	2
	2002	176	23	27	3	149	8	697	11	62	4	91	3

Table 3.3.--Sample sizes for age and length data collected from Alaska sablefish. Japanese fishery data from Sasaki (1985), U.S. fishery data from the observer databases, and longline survey data from longline survey databases. All fish were sexed before measurement, except for the Japanese fishery data.

	LENGTH						**AGE**		
	Japanese fishery		**U.S. fishery**		**Cooperative longline survey**	**Domestic longline survey**	**Cooperative longline survey**	**Domestic longline survey**	**U.S. longline fishery**
Year	**Trawl**	**Longline**	**Trawl**	**Longline**					
1963		30,562							
1964	3,337	11,377							
1965	6,267	9,631							
1966	27,459	13,802							
1967	31,868	12,700							
1968	17,727								
1969	3,843								
1970	3,456								
1971	5,848	19,653							
1972	1,560	8,217							
1973	1,678	16,332							
1974		3,330							
1975									
1976		7,704							
1977		1,079							
1978		9,985							
1979		1,292			19,349				
1980		1,944							
1981							1,146		
1982									
1983							889		
1984									
1985							1,294		
1986									
1987							1,057		
1988									
1989							655		
1990			1,229	33,822		101,530			
1991			721	29,615		95,364	902		
1992			0	21,000		104,786			
1993			468	23,884		94,699	1,178		
1994			89	13,614		70,431			
1995			87	18,174		80,826			
1996			239	15,213		72,247		1,175	
1997			0	20,311		82,783		1,211	
1998			35	8,900		57,773		1,183	
1999			1,268	26,662		79,451		1,188	1,145
2000			472	29,240		62,513		1,236	1,152
2001			473	30,362		83,726		1,214	1,023
2002			526	35,380		75,937		1,136	1,061
2003			503	37,386		77,678		1,198	1,128
2004						82,767			

Table 3.4.--Sablefish abundance index values (1,000's) for Alaska (200-1,000 m) including deep gully habitat, from the Japan-U.S. Cooperative Longline Survey, Domestic Longline Survey, and Japanese and U.S. longline fisheries. Relative population number equals catch per effort in numbers weighted by respective strata areas. Relative population weight equals catch per effort measured in weight multiplied by strata areas. Indices were extrapolated for survey areas not sampled every year, including Aleutian Islands 1979, 1995, 1997, 1999, 2001, and 2003 and Bering Sea 1979-1981, 1995, 1996, 1998, 2000, and 2002.

	RELATIVE POPULATION NUMBER		RELATIVE POPULATION WEIGHT			
Year	Cooperative longline survey	Domestic longline survey	Japanese longline fishery	Cooperative longline survey	Domestic longline survey	U.S. fishery
1964			1,452			
1965			1,806			
1966			2,462			
1967			2,855			
1968			2,336			
1969			2,443			
1970			2,912			
1971			2,401			
1972			2,247			
1973			2,318			
1974			2,295			
1975			1,953			
1976			1,780			
1977			1,511			
1978			942			
1979	413		809	1,075		
1980	388		1,040	968		
1981	460		1,343	1,153		
1982	613			1,572		
1983	621			1,595		
1984	685			1,822		
1985	903			2,569		
1986	838			2,456		
1987	667			2,068		
1988	707			2,088		
1989	661			2,178		
1990	450	649		1,454	2,141	1,201
1991	386	593		1,321	2,071	1,066
1992	402	511		1,390	1,758	908
1993	395	563		1,318	1,894	904
1994	366	489		1,288	1,882	822
1995		501			1,803	1,243
1996		520			2,017	1,201
1997		491			1,764	1,341
1998		466			1,662	1,130
1999		511			1,740	1,209
2000		461			1,597	1,152
2001		533			1,798	1,209
2002		559			1,916	1,226
2003		532			1,759	1,079
2004		544			1,664	

Table 3.5.--Average catch rate (pounds/hook) for fishery data by year and region. SE = standard error, CV = coefficient of variation. The standard error is not available when vessel sample size equals one.

Observer Fishery Data

Bering Sea

Year	CPUE	SE	CV	# Sets	Vessels
1990	0.37	0.07	0.10	715	39
1991	0.26	0.11	0.21	55	15
1992	0.15	0.06	0.20	13	6
1993	0.13	0.08	0.30	29	4
1994	0.32	0.36	0.57	8	4
1995	0.38	0.11	0.15	60	16
1996	0.44	0.16	0.19	51	17
1997	0.30	0.11	0.19	30	10
1998	0.24	0.10	0.21	38	10
1999	0.17	0.05	0.16	49	17
2000	0.22	0.06	0.14	36	12
2001	0.46	0.14	0.16	91	26
2002	0.21	0.09	0.21	20	8
2003	0.06	0.03	0.26	35	8

Aleutian Islands

Year	CPUE	SE	CV	# Sets	Vessels
1990	0.51	0.20	0.20	182	7
1991	0.45	0.06	0.07	547	17
1992	0.39	0.07	0.09	369	11
1993	0.28	0.07	0.13	705	10
1994	0.29	0.08	0.14	405	22
1995	0.29	0.06	0.10	345	15
1996	0.23	0.04	0.08	251	18
1997	0.37	0.10	0.14	157	11
1998	0.23	0.06	0.13	94	10
1999	0.31	0.08	0.14	369	16
2000	0.28	0.07	0.12	377	16
2001	0.28	0.09	0.16	238	9
2002	0.32	0.07	0.10	280	12
2003	0.13	0.06	0.22	226	12

Western Gulf

Year	CPUE	SE	CV	# Sets	Vessels
1990	0.54	0.23	0.21	214	10
1991	0.43	0.11	0.12	284	9
1992	0.32	0.04	0.07	522	25
1993	0.29	0.05	0.09	214	6
1994	0.29	0.07	0.12	78	5
1995	0.56	0.18	0.17	508	22
1996	0.53	0.09	0.09	302	22
1997	0.47	0.08	0.09	375	21
1998	0.46	0.05	0.05	337	15
1999	0.60	0.07	0.06	377	23
2000	0.50	0.10	0.10	233	16
2001	0.55	0.13	0.11	404	19
2002	0.57	0.10	0.09	485	18
2003	0.55	0.11	0.10	573	20

Central Gulf

Year	CPUE	SE	CV	# Sets	Vessels
1990	0.59	0.10	0.08	816	51
1991	0.54	0.13	0.12	666	11
1992	0.56	0.09	0.08	764	41
1993	0.76	0.51	0.34	1191	7
1994	0.53	0.13	0.12	474	25
1995	0.80	0.09	0.06	749	37
1996	0.85	0.10	0.06	599	59
1997	0.92	0.10	0.06	567	51
1998	0.85	0.09	0.05	508	39
1999	0.89	0.13	0.07	338	38
2000	0.84	0.11	0.06	419	50
2001	0.73	0.11	0.08	300	34
2002	0.83	0.13	0.08	320	32
2003	1.02	0.15	0.07	324	35

West Yakutat

Year	CPUE	SE	CV	# Sets	Vessels
1990	0.65	0.16	0.13	135	19
1991	0.63	0.16	0.13	300	9
1992	0.54	0.21	0.20	314	20
1993	0.57	0.12	0.11	515	5
1994	0.55	0.29	0.27	124	8
1995	0.98	0.18	0.09	267	23
1996	0.90	0.13	0.07	284	33
1997	1.21	0.18	0.08	177	29
1998	1.11	0.16	0.07	226	32
1999	1.32	0.28	0.11	117	21
2000	1.39	0.22	0.08	207	33
2001	1.05	0.14	0.07	229	32
2002	1.26	0.23	0.93	210	27
2003	1.41	0.19	0.07	241	31

East Yakutat / Southeast

Year	CPUE	SE	CV	# Sets	Vessels
1990	0.60	0.60	0.51	39	3
1991	0.69	0.27	0.20	57	5
1992	0.62	0.27	0.22	47	4
1993	0.80	0.03	0.02	40	2
1994	0.32			5	1
1995	1.21	0.32	0.14	164	18
1996	1.10	0.19	0.09	185	30
1997	1.26	0.24	0.10	157	38
1998	1.21	0.18	0.08	260	34
1999	1.09	0.17	0.08	135	18
2000	0.99	0.27	0.14	91	17
2001	0.92	0.14	0.07	179	17
2002	1.17	0.36	0.15	147	19
2003	1.32	1.11	0.08	155	26

Table 3.5 cont.

Required Logbook Fishery Data

Bering Sea

Year	CPUE	SE	CV	# Sets	Vessels
1999	0.52	0.14	0.14	523	52
2000	0.19	0.09	0.23	530	28
2001	0.39	0.16	0.21	241	17

Aleutian Islands

Year	CPUE	SE	CV	# Sets	Vessels
1999	0.36	0.17	0.24	475	17
2000	0.19	0.06	0.16	1008	28
2001	0.32	0.13	0.21	358	18

Western Gulf

Year	CPUE	SE	CV	# Sets	Vessels
1999	0.56	0.13	0.12	394	23
2000	0.60	0.10	0.09	667	44
2001	0.61	0.12	0.10	463	37

Central Gulf

Year	CPUE	SE	CV	# Sets	Vessels
1999	0.84	0.15	0.09	807	83
2000	0.79	0.08	0.05	1253	127
2001	0.70	0.09	0.07	1179	135

West Yakutat

Year	CPUE	SE	CV	# Sets	Vessels
1999	1.11	0.23	0.10	210	36
2000	1.07	0.10	0.05	463	59
2001	1.01	0.14	0.07	451	72

East Yakutat / Southeast

Year	CPUE	SE	CV	# Sets	Vessels
1999	0.93	0.15	0.08	169	16
2000	0.98	0.17	0.09	325	40
2001	1.02	0.23	0.11	277	36

Table 3.6.–Sablefish abundance (relative population weight, RPW) from annual sablefish longline surveys (domestic longline survey only) and number of stations where sperm whale (SW) and killer whale (KW) depredation of sablefish catches occurred. Some stations were not sampled all years, indicated by “na”. Recording of sperm whale depredation began with the 1998 survey.

Year	Bering			Aleutians			Western		
	RPW	SW	KW	RPW	SW	KW	RPW	SW	KW
1990	na	na	na	Na	na	na	244,164	na	0
1991	na	na	na	Na	na	na	203,357	na	1
1992	na	na	na	Na	na	na	94,874	na	1
1993	na	na	na	Na	na	na	234,169	na	2
1994	na	na	na	Na	na	na	176,820	na	0
1995	na	na	na	Na	na	na	198,247	na	0
1996	na	na	na	186,270	na	1	213,126	na	0
1997	160,300	na	3	Na	na	na	182,189	na	0
1998	na	na	na	271,323	0	1	203,590	0	0
1999	136,313	0	7	na	na	na	192,191	0	0
2000	na	na	na	260,665	0	1	242,707	0	1
2001	248,019	0	4	na	na	na	294,277	0	0
2002	na	na	na	292,425	0	1	256,548	0	4
2003	232,996	0	7	na	na	na	258,996	0	3

Year	Central			West Yakutat			East Yakutat / Southeast		
	RPW	SW	KW	RPW	SW	KW	RPW	SW	KW
1990	684,738	na	0	268,334	na	0	393,964	na	0
1991	641,693	na	0	287,103	na	0	532,242	na	0
1992	568,474	na	0	316,770	na	0	475,528	na	0
1993	639,161	na	0	304,701	na	0	447,362	na	0
1994	603,940	na	0	275,281	na	0	434,840	na	0
1995	595,903	na	0	245,075	na	0	388,858	na	0
1996	783,763	na	0	248,847	na	0	390,696	na	0
1997	683,294	na	0	216,415	na	0	358,229	na	0
1998	519,781	0	0	178,783	4	0	349,350	0	0
1999	608,225	3	0	183,129	5	0	334,516	4	0
2000	506,368	0	0	158,411	2	0	303,716	2	0
2001	561,168	3	0	129,620	0	0	290,747	2	0
2002	643,363	4	0	171,985	3	0	287,133	2	0
2003	605,417	1	0	146,631	1	0	245,367	2	0

Table 3.7a.– Ages that above average year classes became abundant by region (Figure 3.7, relative population number greater than 10,000). “Western” includes the Bering Sea, Aleutian Islands, and western Gulf of Alaska. Age data was not available for the Western areas until 1985. The 1984 year class never was abundant in the Eastern area. The 1995 year class was only moderately abundant in the Central and Eastern areas. The 2000 year class has almost reached in the RPN threshold at age 3 (in 2003).

Year class	Western	Central	Eastern
1977	na	4	4
1980-81	5	6	6
1984	5	9	na
1990	6	7	7
1995	4	7	7
1997	4	4	5
2000	na	na	na

Table 3.7b– Years that the above average 1995 and 1997 year classes became abundant by region. “Western” includes the Bering Sea, Aleutian Islands, and western Gulf of Alaska. The 2000 year class is predicted to appear in the Central and Eastern areas in 2005 or 2006.

Year class	Western	Central	Eastern
1995	1999	2002	2002
1997	2001	2001	2002
2000	2004	2005-06 (pred.)	2005-06 (pred.)

Table 3.8.--Sablefish fork length (cm), weight (kg), and proportion mature by age and sex.

	Fork length (cm)		Weight (kg)		Fraction mature	
Age	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
2	50	52	1.3	1.4	0.059	0.006
3	53	56	1.5	1.8	0.165	0.024
4	55	59	1.7	2.1	0.343	0.077
5	57	62	1.9	2.4	0.543	0.198
6	59	64	2.1	2.7	0.704	0.394
7	61	66	2.3	3.0	0.811	0.604
8	62	68	2.5	3.3	0.876	0.765
9	63	70	2.6	3.6	0.915	0.865
10	64	71	2.7	3.8	0.939	0.921
11	65	72	2.8	4.1	0.954	0.952
12	65	74	2.9	4.3	0.964	0.969
13	66	75	3.0	4.5	0.971	0.979
14	66	76	3.1	4.7	0.976	0.986
15	67	76	3.1	4.8	0.979	0.990
16	67	77	3.2	5.0	0.982	0.992
17	67	78	3.2	5.1	0.984	0.994
18	67	78	3.2	5.2	0.985	0.995
19	68	79	3.3	5.3	0.986	0.996
20	68	79	3.3	5.4	0.987	0.997
21	68	80	3.3	5.5	0.988	0.997
22	68	80	3.3	5.6	0.988	0.998
23	68	80	3.4	5.7	0.989	0.998
24	68	81	3.4	5.7	0.989	0.998
25	68	81	3.4	5.8	0.989	0.998
26	68	81	3.4	5.8	0.990	0.998
27	68	81	3.4	5.9	0.990	0.999
28	69	81	3.4	5.9	0.990	0.999
29	69	82	3.4	5.9	0.990	0.999
30	69	82	3.4	6.0	0.990	0.999

Table 3.9.--Sablefish age 4+ biomass, exploitable biomass, spawning biomass, and catch (thousands mt), and number (millions) at age 2 by year.

Year	Age 4+ biomass	Exploitable biomass	Spawning biomass	Number (millions) at age 2	Catch	Catch / Age 4+ biomass
1960	312	292	270	4.2	3.1	0.010
1961	300	287	266	5.0	16.1	0.054
1962	274	266	248	31.3	26.4	0.096
1963	240	234	222	117.9	16.9	0.071
1964	260	227	218	4.0	7.3	0.028
1965	435	276	246	3.7	8.7	0.020
1966	438	370	299	11.0	15.6	0.036
1967	426	409	345	79.2	19.2	0.045
1968	411	400	364	4.4	31.0	0.075
1969	486	387	351	6.0	36.8	0.076
1970	447	404	351	61.1	37.8	0.085
1971	402	390	346	7.2	43.5	0.108
1972	438	363	332	6.8	53.0	0.121
1973	377	340	296	4.1	36.9	0.098
1974	343	327	289	2.3	34.6	0.101
1975	299	290	266	2.0	29.9	0.100
1976	255	250	232	18.6	31.7	0.124
1977	210	208	195	8.0	21.4	0.102
1978	205	183	172	4.0	10.4	0.051
1979	200	181	167	77.4	11.9	0.060
1980	185	180	166	37.0	10.4	0.056
1981	294	200	183	5.3	12.6	0.043
1982	343	258	214	54.9	12.0	0.035
1983	343	314	259	44.6	11.8	0.034
1984	416	344	301	3.0	14.1	0.034
1985	466	422	329	7.2	14.5	0.031
1986	449	439	355	33.8	28.9	0.064
1987	419	418	362	8.4	35.2	0.084
1988	415	390	338	10.7	38.4	0.093
1989	369	359	306	3.5	34.8	0.094
1990	336	327	285	23.2	32.1	0.095
1991	293	293	262	6.4	27.0	0.092
1992	286	270	236	23.2	24.9	0.087
1993	260	256	221	14.4	25.4	0.098
1994	263	247	210	9.8	23.8	0.091
1995	254	225	203	6.7	20.9	0.082
1996	241	220	196	11.1	17.6	0.073
1997	227	213	193	21.3	14.9	0.066
1998	219	203	186	5.8	14.1	0.064
1999	233	201	183	38.1	13.6	0.058
2000	219	202	181	14.3	15.9	0.073
2001	258	208	186	3.9	14.1	0.055
2002	261	224	194	30.9	14.8	0.057
2003	247	233	202	4.9	16.5	0.067
2004	272	231	208	8.9	17.6	0.065
2005	253	232	204			

Table 3.10--Sablefish spawning biomass, fishing mortality, and yield for seven harvest scenarios. Abundance projected using 1977-2000 year classes. Sablefish are not classified as overfished because abundance currently exceeds $B_{35\%}$.

Year	Maximum permissible F	Fraction maximum F	Half maximum F	5-year average F	No fishing	Overfished?	Approaching overfished?
Spawning biomass							
2004	208	208	208	208	208	208	208
2005	204	204	204	204	204	204	205
2006	200	200	209	204	219	196	204
2007	194	194	210	201	230	187	202
2008	190	190	213	199	241	182	199
2009	193	193	220	203	257	183	199
2010	200	200	232	212	279	189	202
2011	206	206	244	220	299	194	204
2012	210	210	252	226	316	196	205
2013	216	216	263	234	338	201	208
2014	219	219	271	240	355	204	208
2015	221	221	277	244	370	205	208
2016	224	224	284	248	387	207	209
2017	225	225	288	251	399	207	209
Fishing mortality							
2004	0.084	0.084	0.084	0.084	0.084	0.084	0.084
2005	0.102	0.102	0.051	0.080	0.000	0.124	0.103
2006	0.100	0.100	0.052	0.080	0.000	0.119	0.102
2007	0.096	0.096	0.052	0.080	0.000	0.113	0.122
2008	0.094	0.094	0.052	0.080	0.000	0.110	0.118
2009	0.094	0.094	0.052	0.080	0.000	0.109	0.117
2010	0.096	0.096	0.053	0.080	0.000	0.111	0.117
2011	0.097	0.097	0.054	0.080	0.000	0.113	0.117
2012	0.098	0.098	0.054	0.080	0.000	0.113	0.117
2013	0.099	0.099	0.054	0.080	0.000	0.115	0.118
2014	0.100	0.100	0.055	0.080	0.000	0.116	0.118
2015	0.101	0.101	0.055	0.080	0.000	0.116	0.118
2016	0.101	0.101	0.055	0.080	0.000	0.117	0.118
2017	0.101	0.101	0.055	0.080	0.000	0.117	0.118
Yield							
2004	17.6	17.6	17.6	17.6	17.6	17.6	17.6
2005	21.0	21.0	10.8	16.6	0.0	25.4	21.4
2006	19.9	19.9	11.1	16.4	0.0	23.1	20.9
2007	18.5	18.5	11.1	15.9	0.0	20.9	24.8
2008	18.4	18.4	11.5	16.2	0.0	20.4	24.3
2009	19.1	19.1	12.1	16.8	0.0	21.1	24.4
2010	20.3	20.3	12.9	17.5	0.0	22.3	24.8
2011	21.2	21.2	13.6	18.2	0.0	23.3	25.3
2012	21.8	21.8	14.2	18.7	0.0	23.9	25.4
2013	22.7	22.7	14.8	19.3	0.0	24.7	25.9
2014	23.2	23.2	15.3	19.7	0.0	25.2	25.9
2015	23.5	23.5	15.7	20.0	0.0	25.4	26.0
2016	23.9	23.9	16.0	20.3	0.0	25.7	26.1
2017	24.0	24.0	16.3	20.5	0.0	25.7	26.0

Table 3.11.--Regional estimates of sablefish age-4+ biomass. Age 4+ biomass was estimated by year and region by applying only survey-based weights, similar to the method used to allocate the ABC (except that the ABC allocation also used fishery data).

Year	Bering Sea	Aleutian Islands	Western Gulf of Alaska	Central Gulf of Alaska	West Yakutat	East Yakutat/ Southeast	Alaska
1960							312
1961							300
1962							274
1963							240
1964							260
1965							435
1966							438
1967							426
1968							411
1969							486
1970							447
1971							402
1972							438
1973							377
1974							343
1975							299
1976							255
1977							210
1978							205
1979	38	41	19	59	17	26	200
1980	35	38	17	55	16	24	185
1981	52	74	29	75	25	39	294
1982	62	82	36	79	32	52	343
1983	62	73	43	85	32	48	343
1984	75	91	61	102	34	53	416
1985	87	108	69	112	36	54	466
1986	90	101	65	111	34	48	449
1987	87	88	58	104	36	46	419
1988	64	93	57	112	39	49	415
1989	49	73	50	114	36	47	369
1990	49	70	39	102	35	42	336
1991	42	52	34	93	32	41	293
1992	29	48	31	91	37	50	286
1993	22	37	26	90	38	48	260
1994	15	37	30	88	42	51	263
1995	19	35	32	82	39	47	254
1996	20	31	28	78	35	49	241
1997	20	25	25	81	31	45	227
1998	19	22	24	82	28	44	219
1999	21	31	27	79	27	48	233
2000	18	32	25	76	24	44	219
2001	21	40	34	86	27	50	258
2002	29	40	39	84	23	47	261
2003	30	38	35	81	22	41	247
2004	35	42	39	92	23	41	272
2005	34	34	32	91	24	38	253

Table 3.12.--Analysis of ecosystem considerations for sablefish fishery.

Indicator	*Observation*	*Interpretation*	*Evaluation*
ECOSYSTEM EFFECTS ON STOCK			
Prey availability or abundance trends			
Zooplankton	None	None	Unknown
Predator population trends			
Salmon	Decreasing	Increases the stock	No concern
Changes in habitat quality			
Temperature regime	Warm increases recruitment	Variable recruitment	No concern (can't affect)
Prevailing currents	Northerly increases recruitment	Variable recruitment	No concern (can't affect)
FISHERY EFFECTS ON ECOSYSTEM			
Fishery contribution to bycatch			
Prohibited species	Small catches	Minor contribution to mortality	No concern
Forage species	Small catches	Minor contribution to mortality	No concern
HAPC biota (seapens/whips, corals, sponges, anemones)	Small catches, except long-term reductions predicted	Long-term reductions predicted in hard corals and living structure	Definite concern
Marine mammals and birds	Bird catch about 10% total	Appears to be decreasing	Possible concern
Sensitive non-target species	Grenadier, spiny dogfish, and unidentified shark catch notable	Grenadier catch high but stable, shark catch is variable	Possible concern for sharks
Fishery concentration in space and time	IFQ less concentrated	IFQ improves	No concern
Fishery effects on amount of large size target fish	IFQ reduces catch of immature	IFQ improves	No concern
Fishery contribution to discards and offal production	sablefish <5% in longline fishery, but 30% in trawl fishery	IFQ improves, but notable discards in trawl fishery	Trawl fishery discards definite concern
Fishery effects on age-at-maturity and fecundity	trawl fishery catches smaller fish, but only small part of total catch	slightly decreases	No concern

Figures

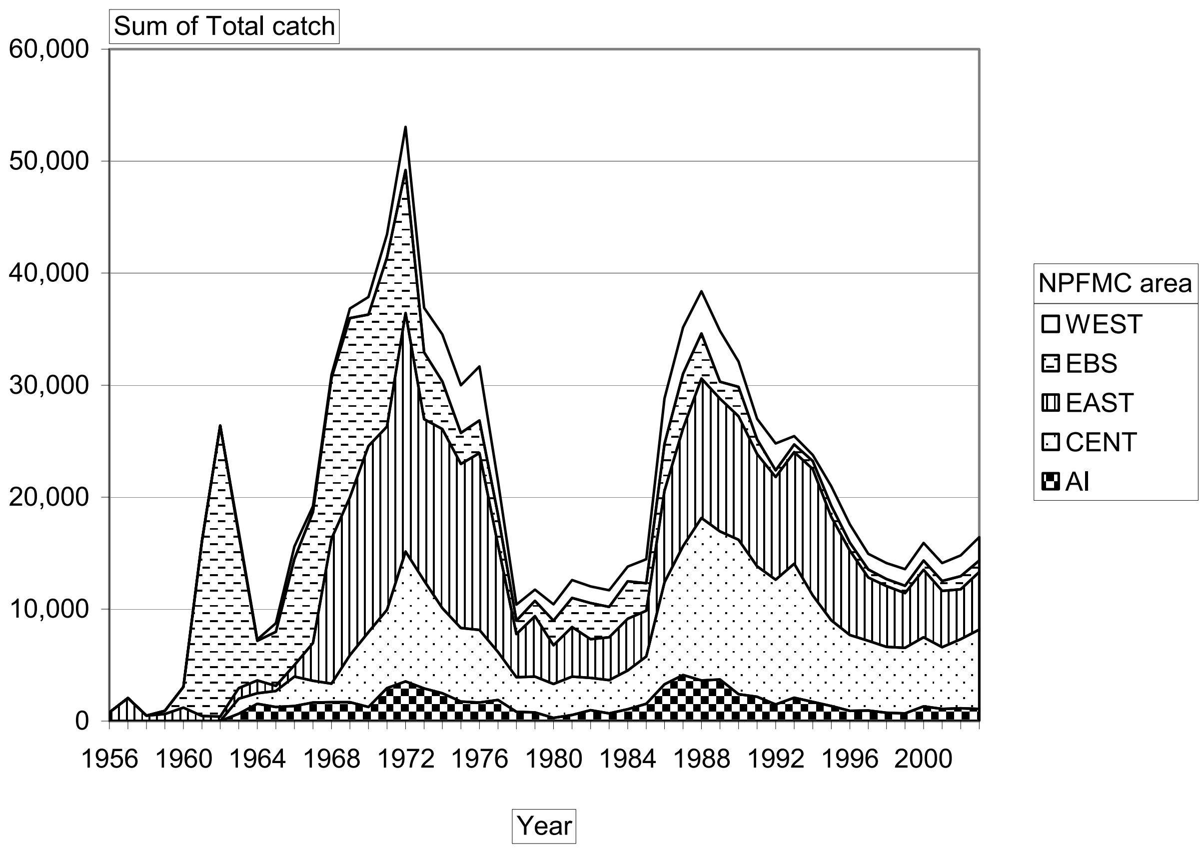


Figure 3.1–Sablefish fishery total reported catch (mt) by North Pacific Fishery Management Council area (WEST is Western Gulf of Alaska, EBS is eastern Bering Sea, EAST is Eastern Gulf of Alaska, CENT is Central Gulf of Alaska, and AI is Aleutian Islands) and year.

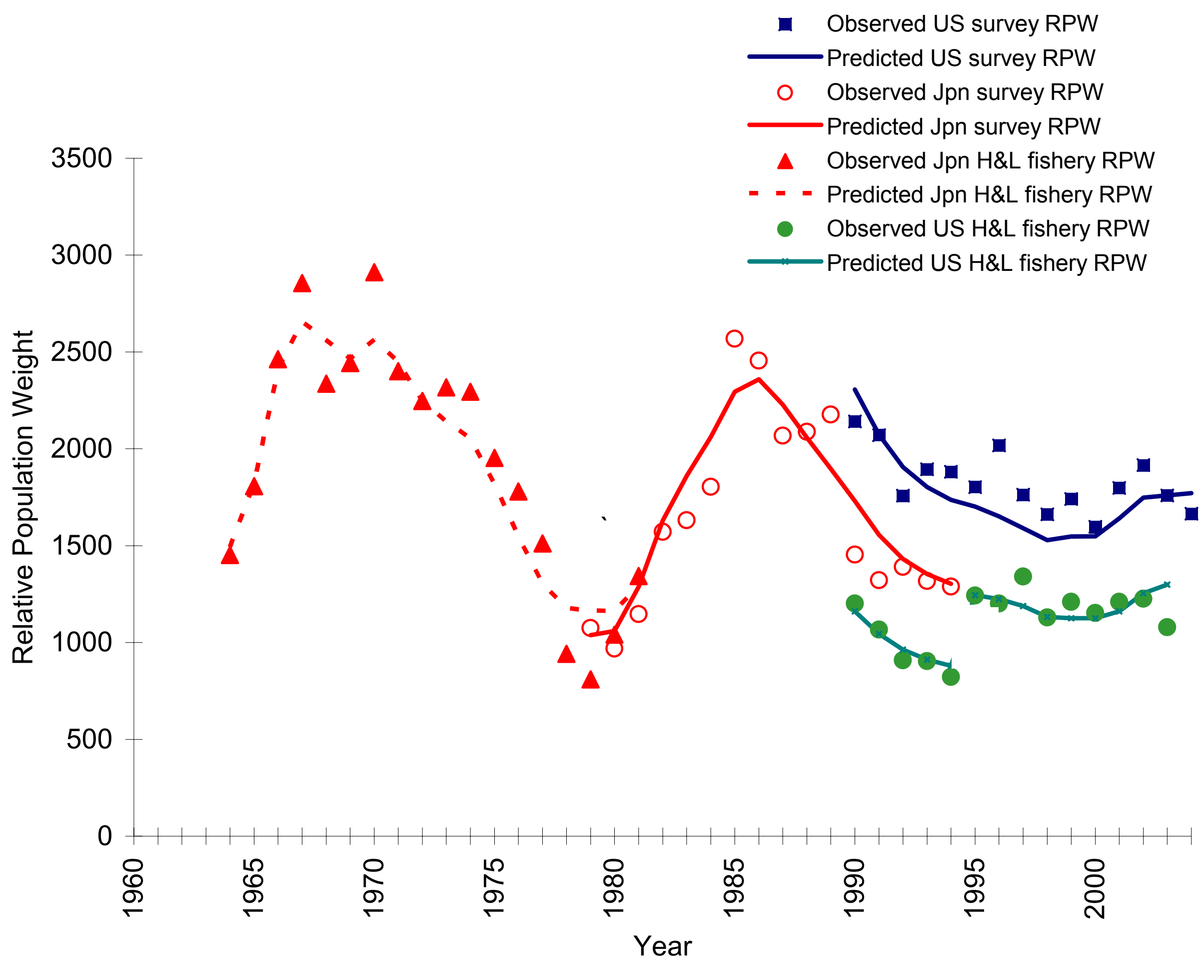


Figure 3.2.--Observed and predicted sablefish relative population weight versus year.

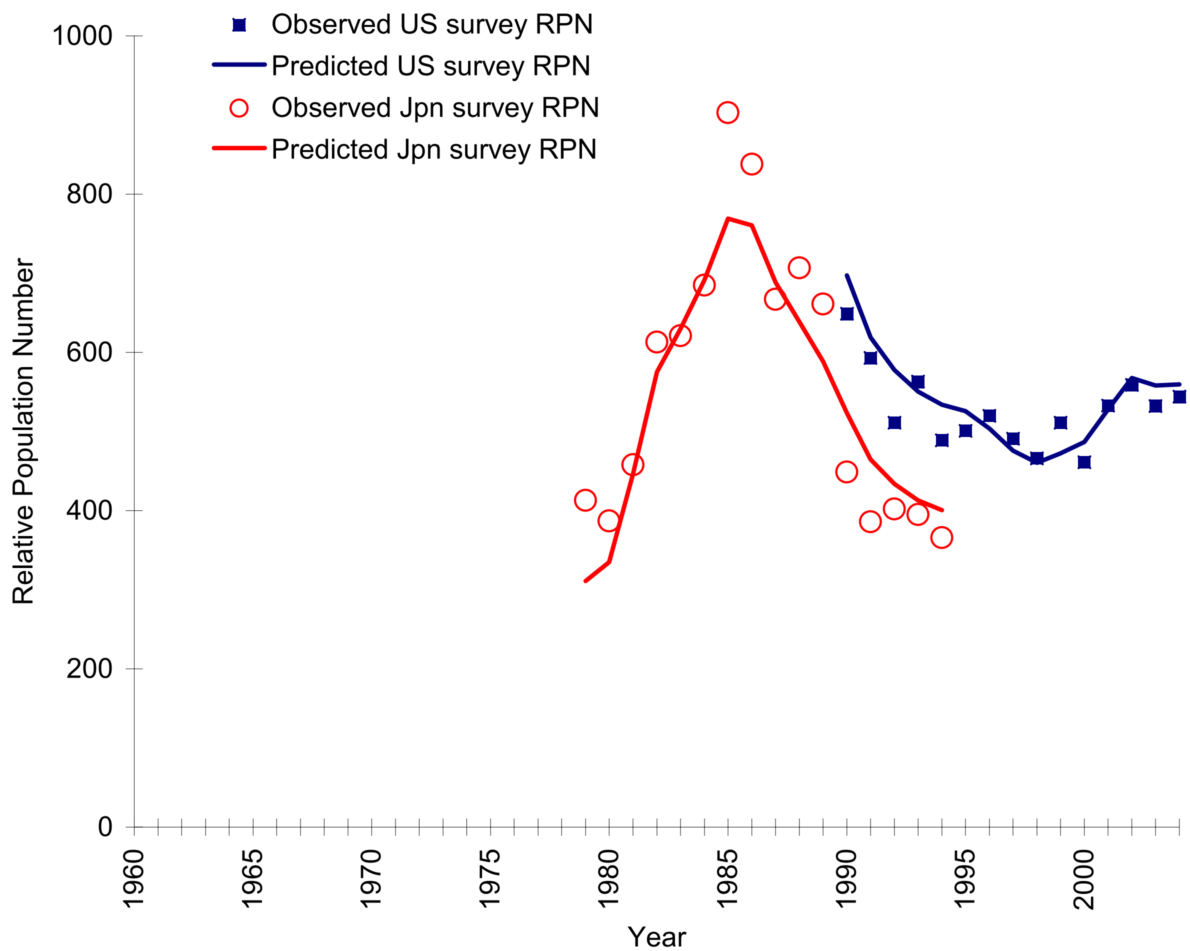


Figure 3.3.--Observed and predicted sablefish relative population number versus year.

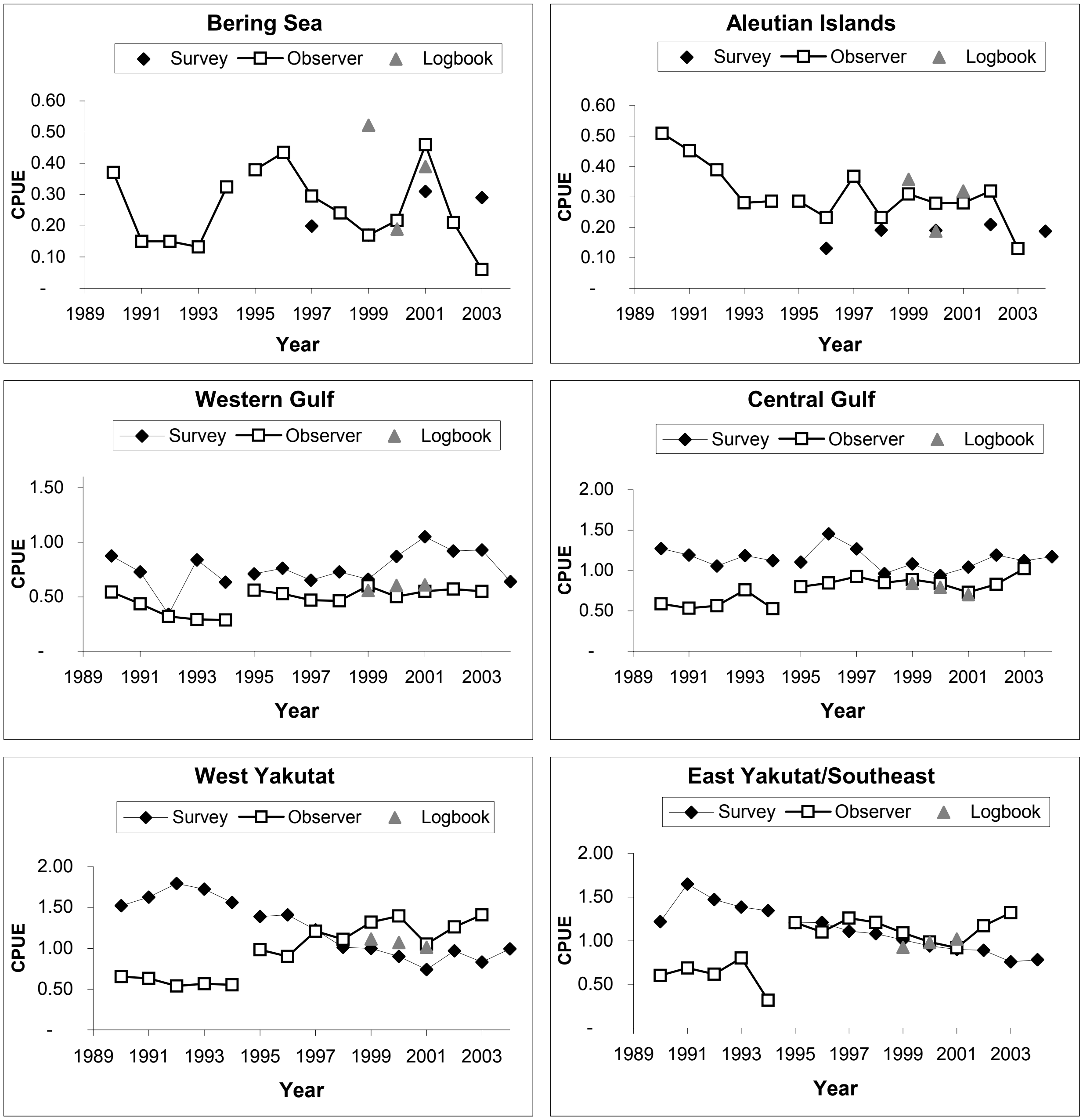


Figure 3.4.–Average fishery catch rate (pounds/hook) by region and data source for longline survey and fishery data. The fishery switched from open-access to individual quota management in 1995.

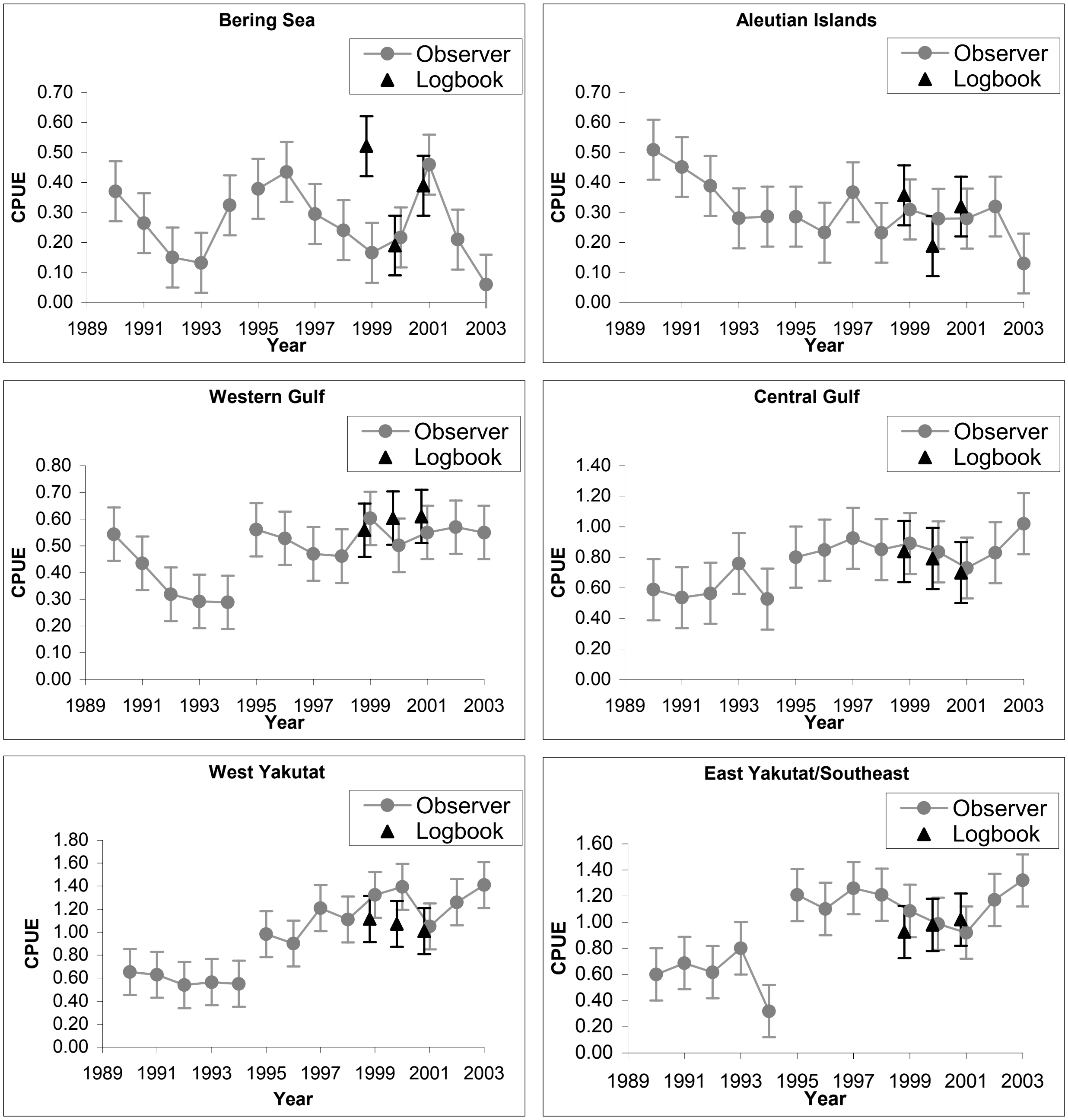


Figure 3.5.–Average fishery catch rate (pounds/hook) and associated 95% confidence intervals by region and data source. The fishery switched from open-access to individual quota management in 1995.

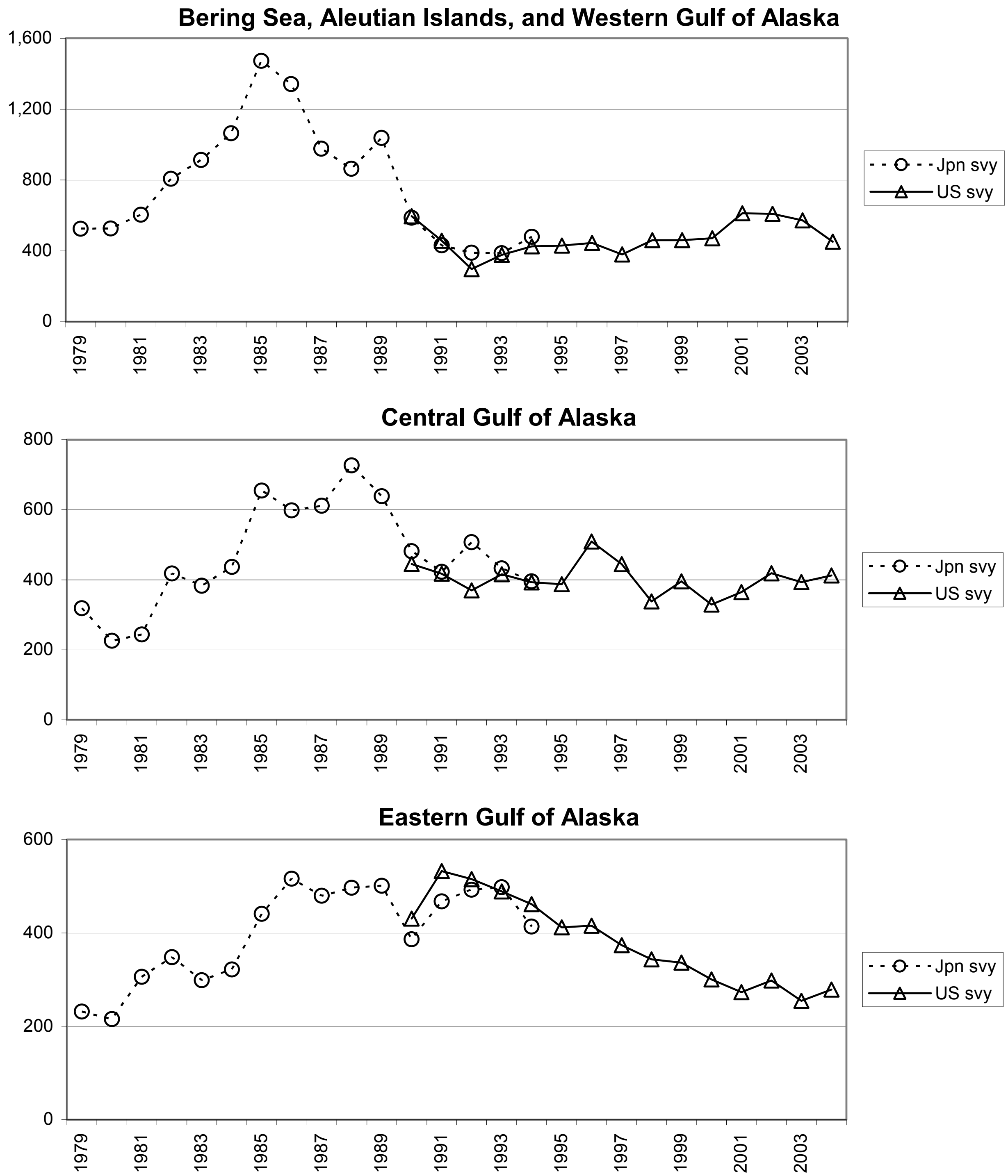


Figure 3.6.—Relative abundance (weight) by region and survey. The regions Bering Sea, Aleutians Islands, and western Gulf of Alaska are combined in the first plot. The two surveys are the Japan-U.S. cooperative longline survey and the domestic (U.S.) longline survey. In this plot, the values for the U.S. survey were adjusted to account for the higher efficiency of the U.S. survey gear.

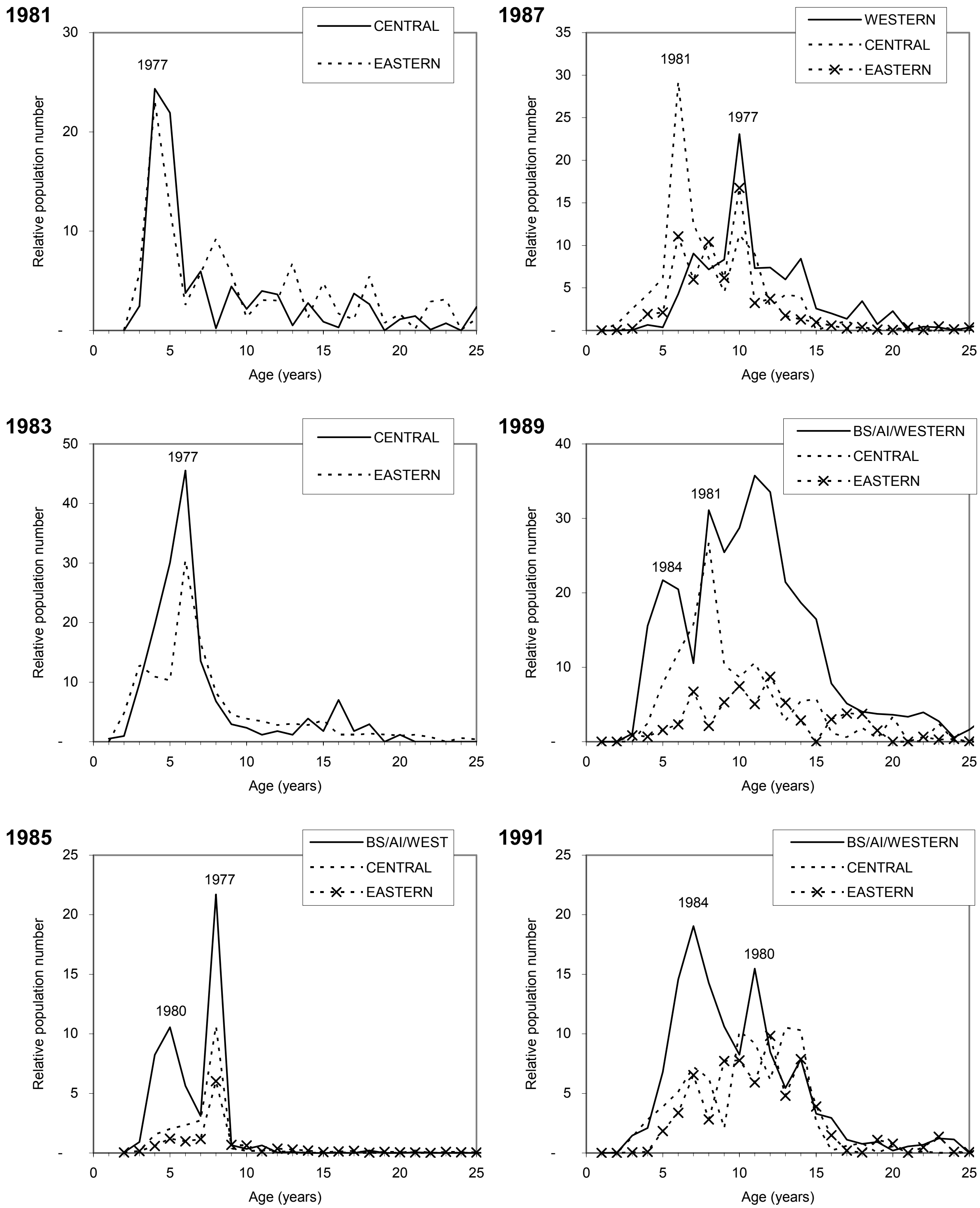


Figure 3.7.—Relative abundance (number, thousands) by age and region. The regions Bering Sea, Aleutian Islands, and Western Gulf of Alaska are combined.

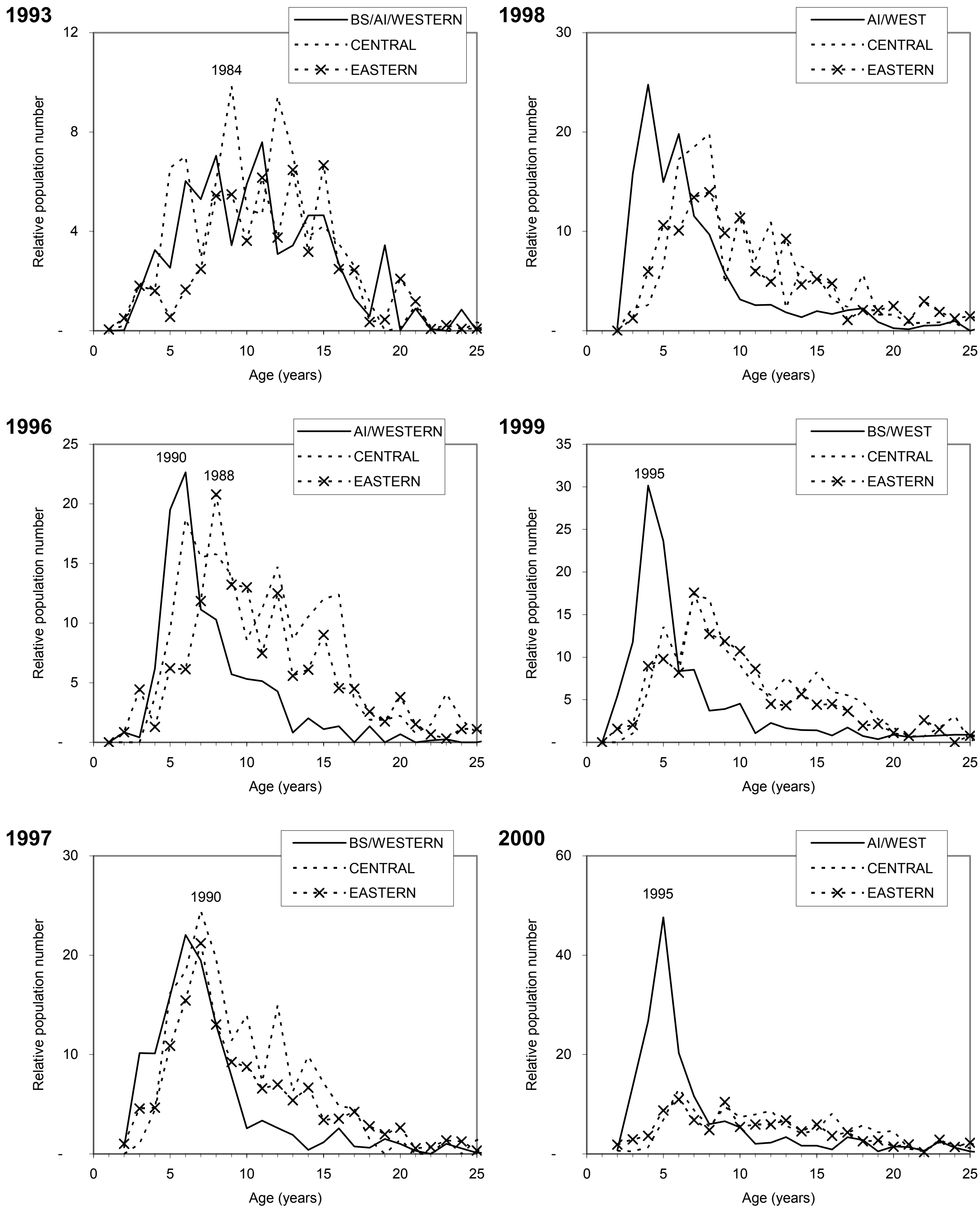


Figure 3.7 cont.

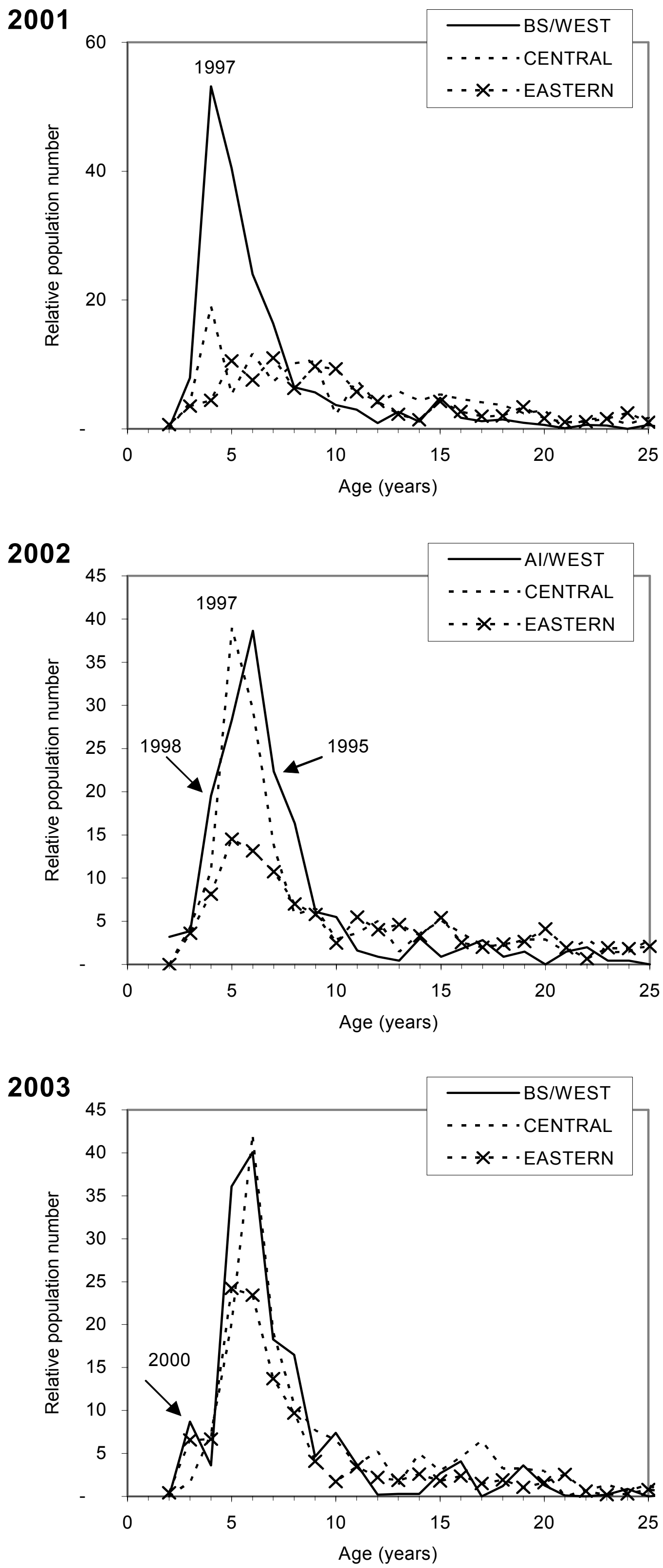


Figure 3.7 cont.

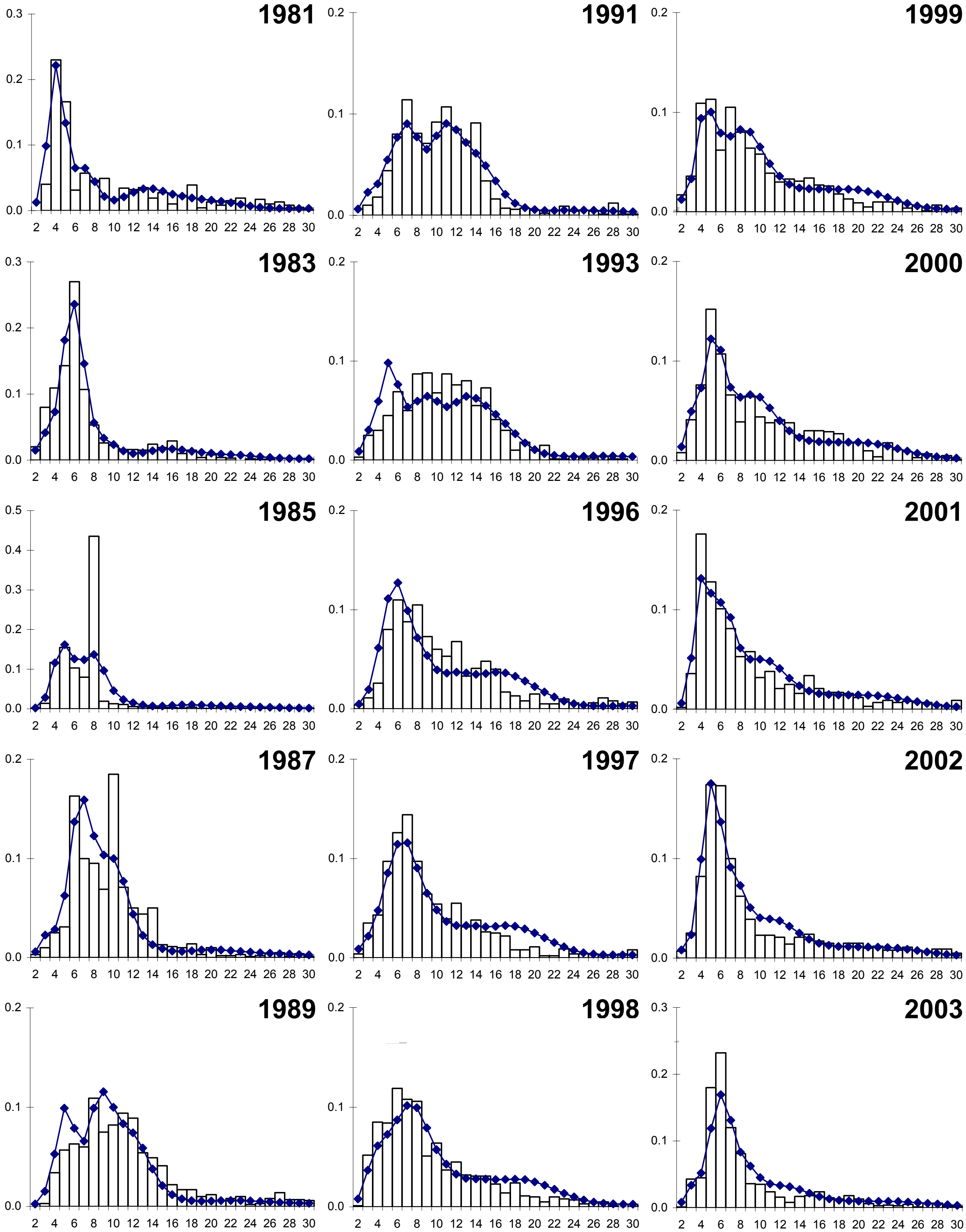


Figure 3.8.—Observed (bar) and predicted (line) sablefish survey age frequency by age group and year.

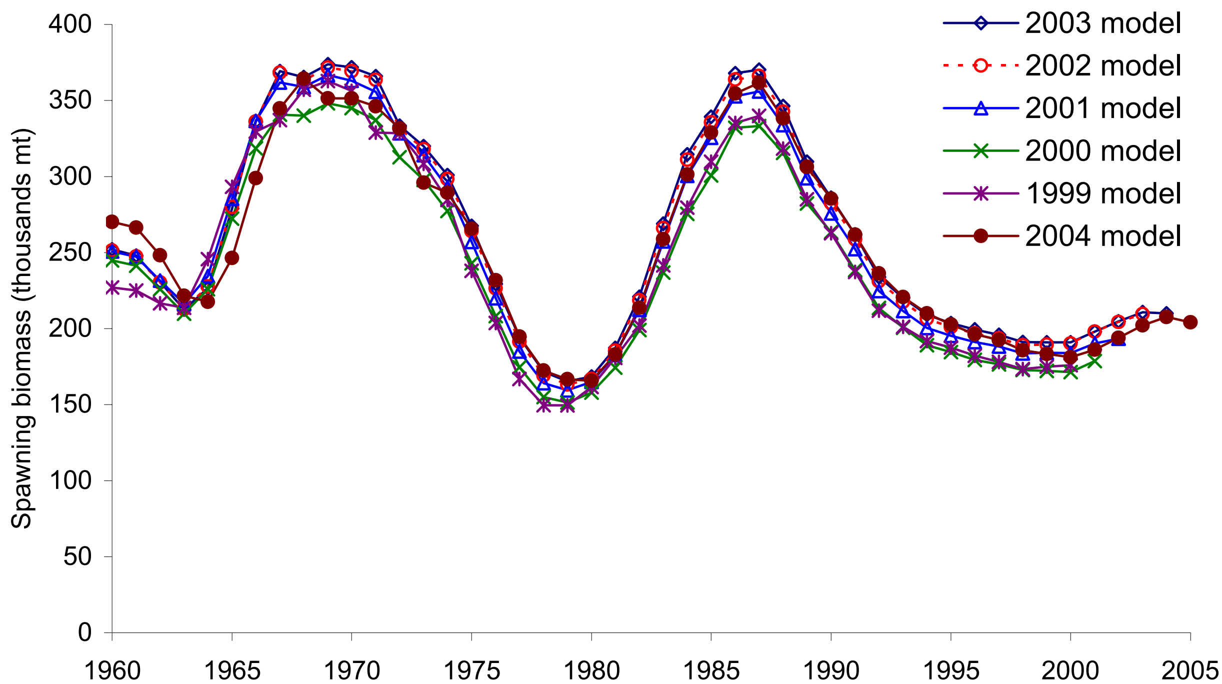


Figure 3.9a.--Estimated and one-year ahead projected sablefish spawning biomass (thousands mt) versus year by assessment model year. The current model is the 2004 assessment model.

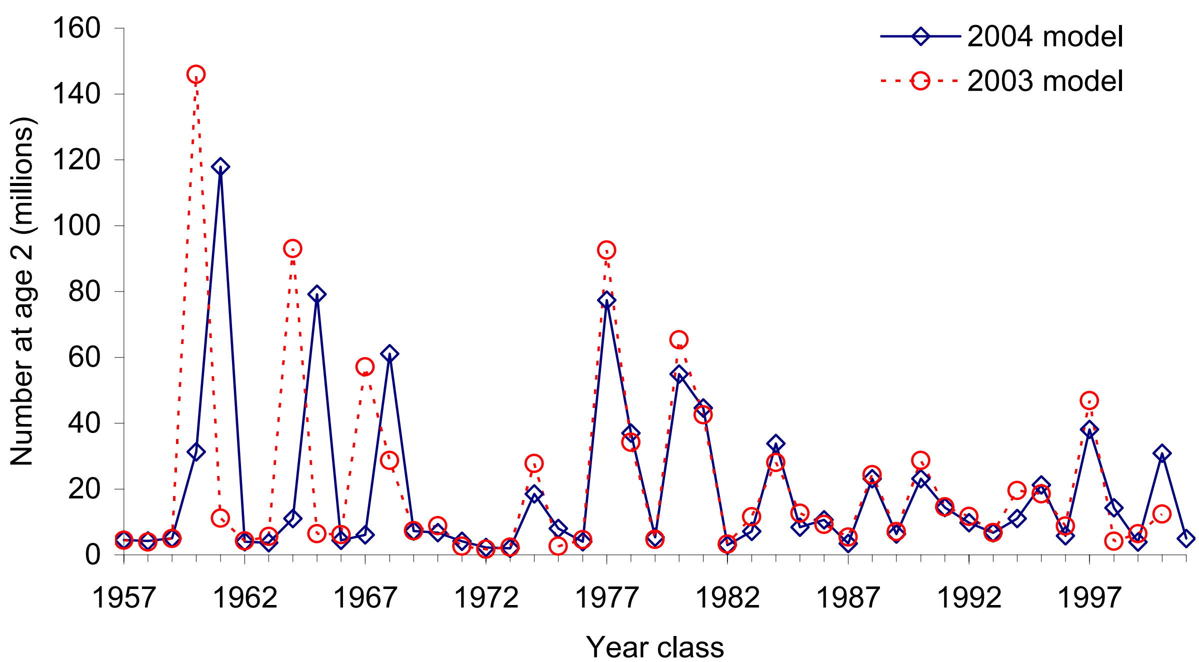


Figure 3.9b.--Estimated recruitment (number at age 2, millions) versus year for the 2003 and 2004 assessment models. Only two years are displayed for display clarity.

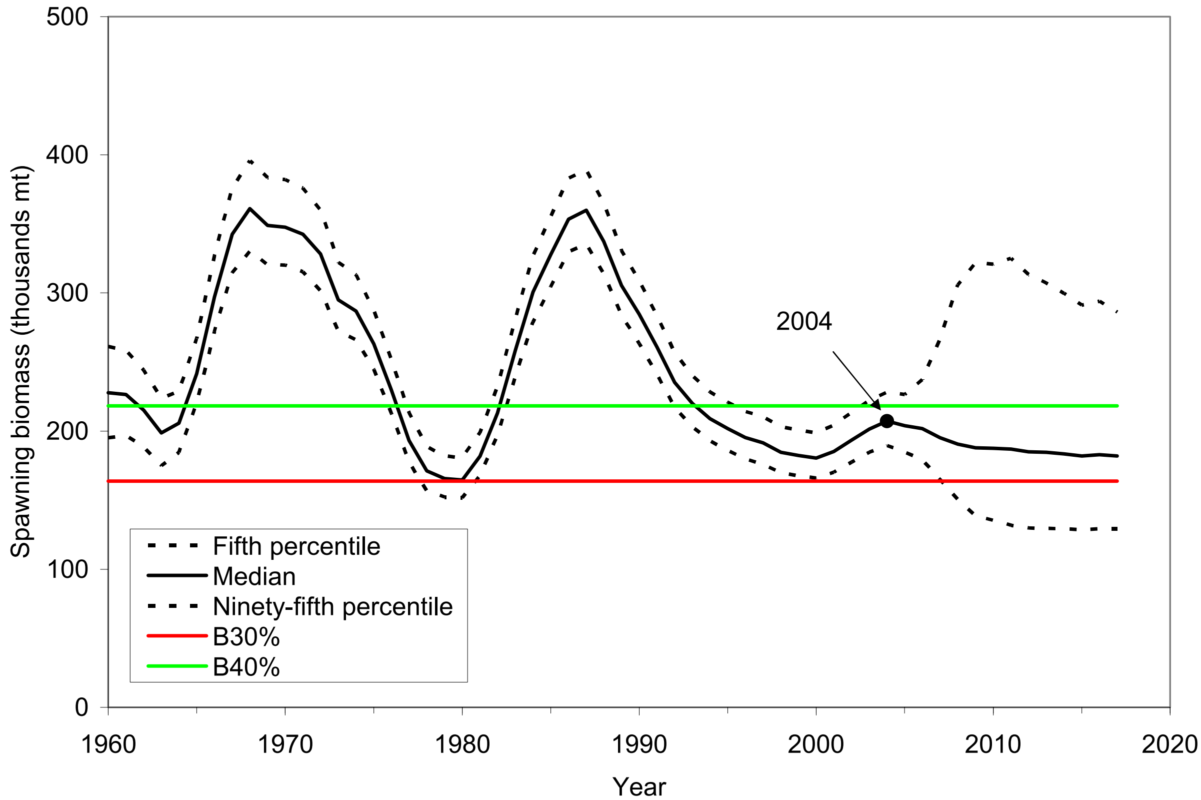


Figure 3.10.--Estimates of male and female spawning biomass (thousands mt) and their uncertainty. Median and 5th and 95th percentiles are based on posterior probability distribution of spawning biomass from Bayesian analysis.

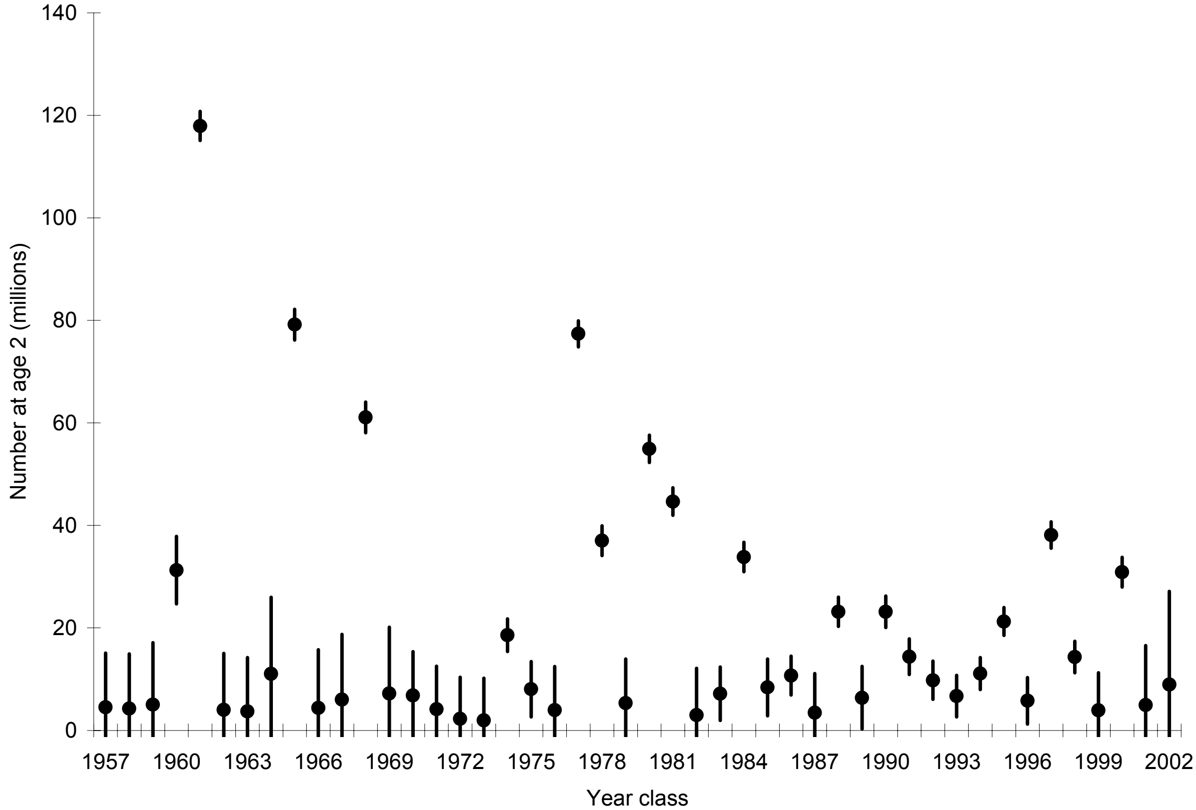


Figure 3.11.--Model estimates of the number of age-2 sablefish (millions) +/- 2 standard errors by year class. Standard error estimates based on covariance matrix from age-structured model output.

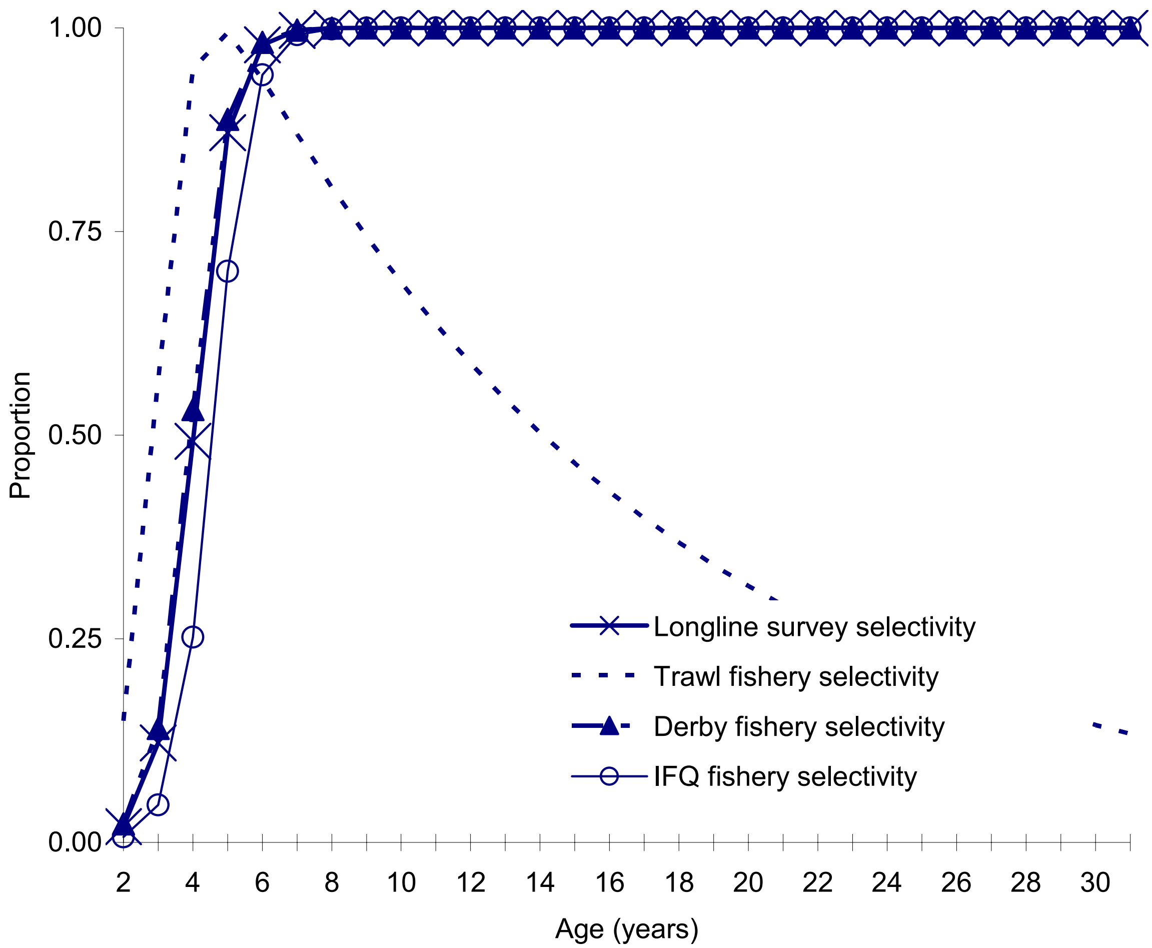


Figure 3.12.--Sablefish survey, IFQ longline fishery, open-access "derby" longline fishery, and trawl fishery selectivity functions.

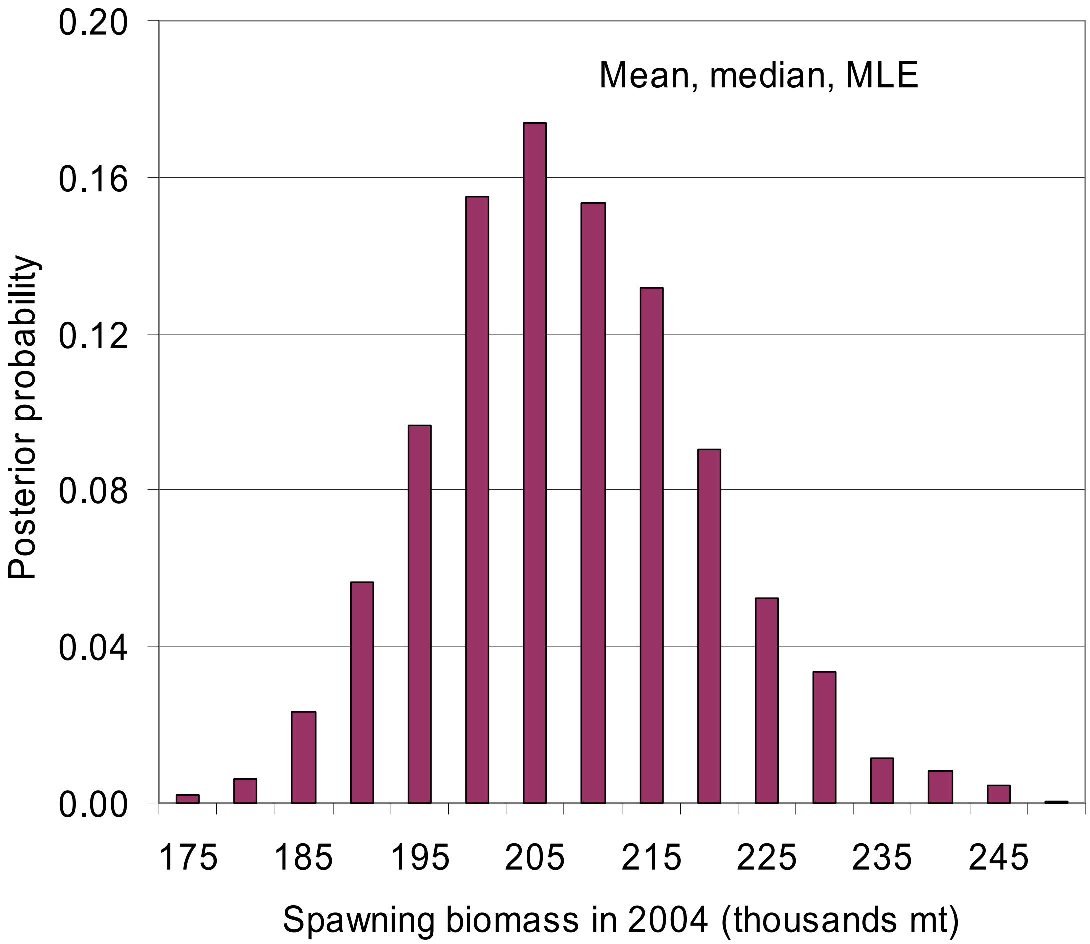


Figure 3.13.--Posterior probability distribution for spawning biomass (thousands mt) in 2004.

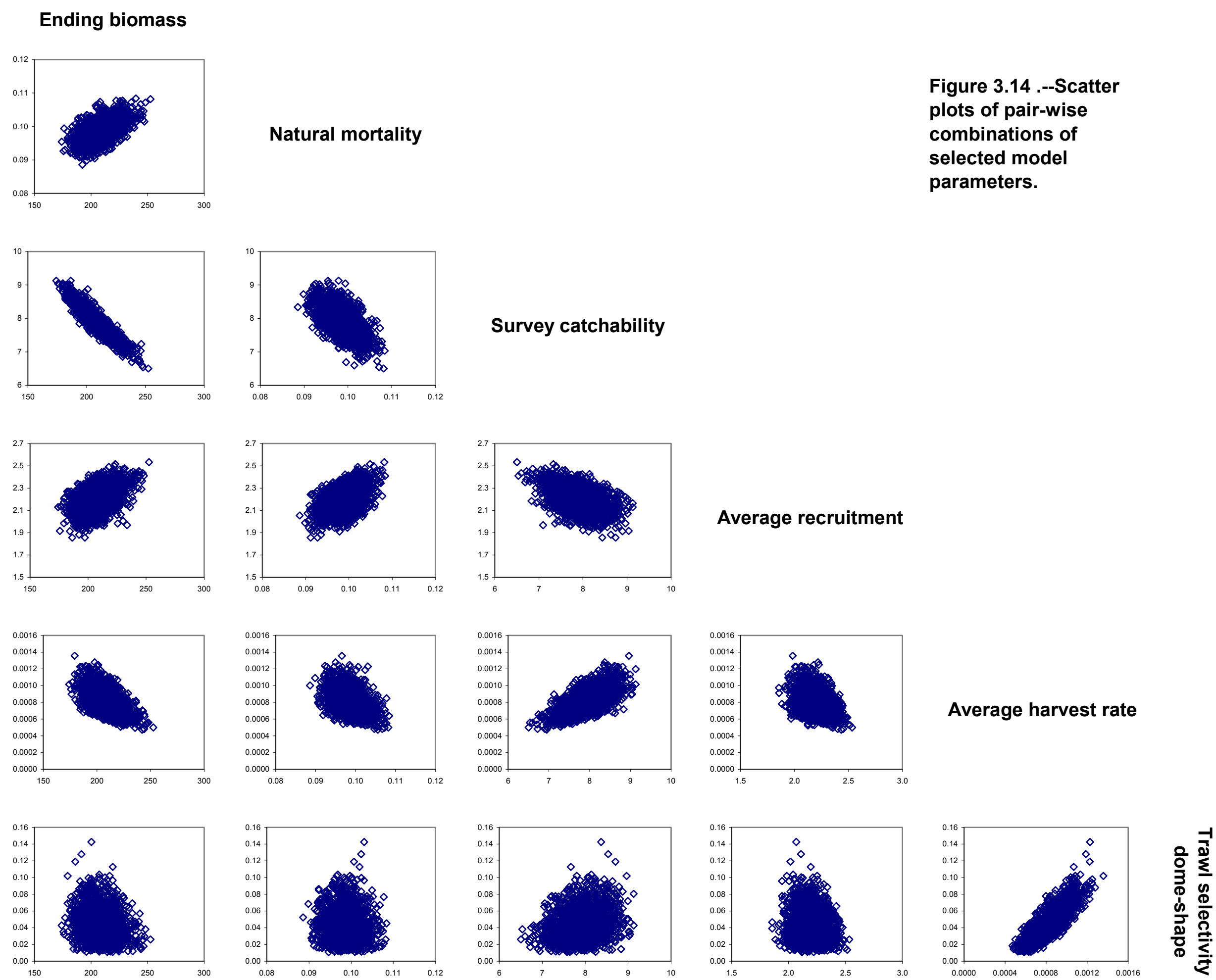
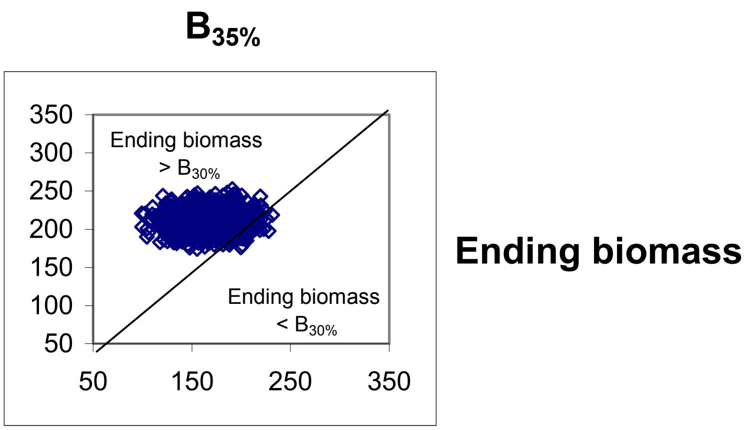


Figure 3.14 .--Scatter plots of pair-wise combinations of selected model parameters.

a.



b.

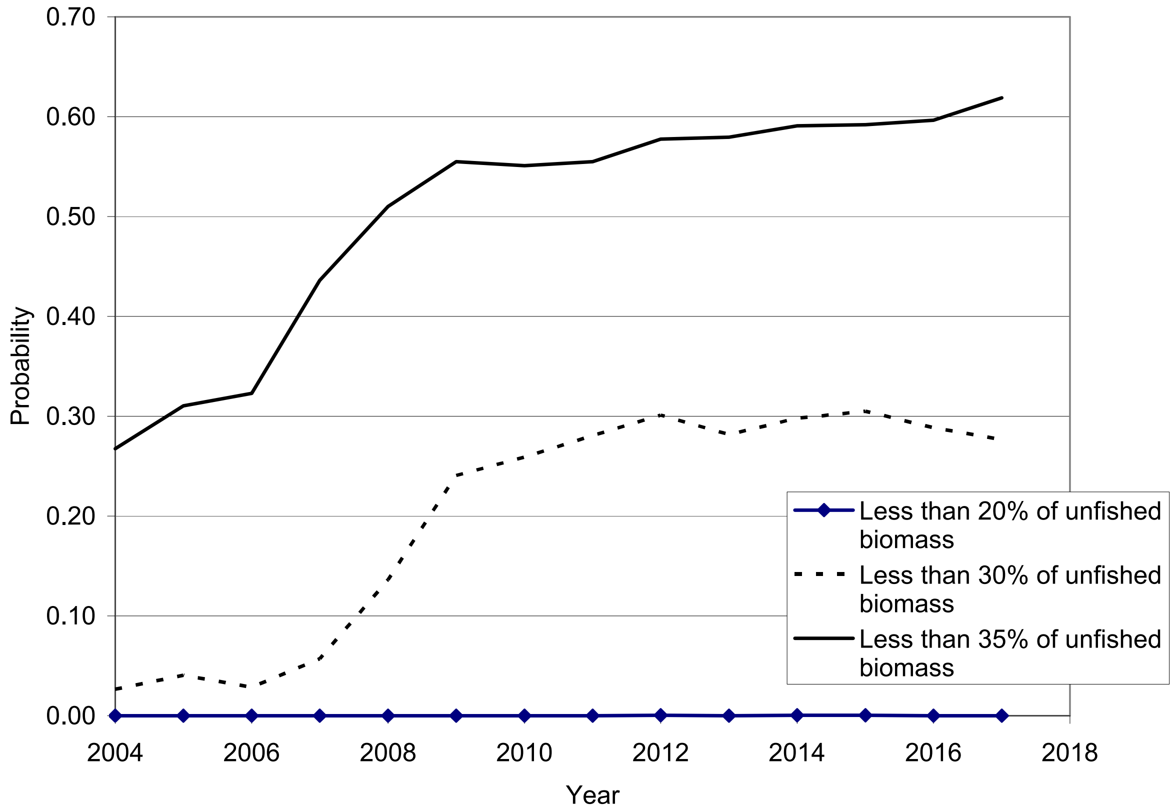


Figure 3.15a.—Ending (2004) biomass was compared to $B_{30\%}$ for each MCMC run and the probability that ending biomass falls below $B_{30\%}$ was estimated (0.03). 3.15b. Probability that projected spawning biomass will fall below $B_{35\%}$, $B_{30\%}$ and $B_{20\%}$. The harvest alternatives are described in section 3.5.1, Standard set of population projections and Decision Analysis.

Appendix A.--Sablefish longline survey - fishery interactions

NMFS has requested the assistance of the fishing fleet to avoid the annual sablefish longline survey since the inception of sablefish IFQ management in 1995. We requested that fishermen stay at least five nautical miles away from each survey station for 7 days before and 3 days after the planned sampling date (3 days allow for survey delays). Beginning in 1998, we also revised the longline survey schedule to avoid the July 1 rockfish trawl fishery opening as well as other short, but less intense fisheries.

History of interactions

Publicity, the revised longline survey schedule, and fishermen cooperation generally have been effective at reducing trawl fishery interactions. No interactions were reported in 2000 and 2002 and only one in 2001.

Distribution of the survey schedule to all IFQ permit holders, radio announcements from the survey vessel, and the threat of a regulatory rolling closure have had intermittent success at reducing the annual number of longline fishery interactions. The number of fishing vessels has been about 10, except 1999, 2001, and 2002, when the numbers were 3, 1, and 3. In 2004, five longline vessels and one pot vessel were contacted by the survey vessel and made sets that interacted with a survey station. Fifty-eight different longline vessels have interacted with the survey vessel since 1995, about 14% of the fleet.

LONGLINE SURVEY - FISHERY INTERACTIONS

	Longline		Trawl		Pot		Total	
Year	Stations	Vessels	Stations	Vessels	Stations	Vessels	Stations	Vessels
1995	8	7	9	15	0	0	17	22
1996	11	18	15	17	0	0	26	35
1997	8	8	8	7	0	0	16	15
1998	10	9	0	0	0	0	10	9
1999	4	4	2	6	0	0	6	10
2000	10	10	0	0	0	0	10	10
2001	1	1	1	1	0	0	2	2
2002	3	3	0	0	0	0	3	3
2003	4	4	2	2	0	0	6	6
2004	5	5	0	0	1	1	6	6

Recommendation

We have followed several practical measures to alleviate fishery interactions with the survey. Trawl fishery interactions generally have decreased; longline fishery interactions decreased in 1999 and 2001-2003. We will continue to work with association representatives and individual fishermen from the longline and trawl fleets to reduce fishery interactions and ensure accurate estimates of sablefish abundance.

Appendix B.--Research survey catches (kg) by survey.

Year	Echo integration trawl	Trawl	Japan US longline survey	Domestic longline survey	Total
1977		3,126			3,126
1978	23	14,302			14,325
1979		27,274	103,839		131,113
1980		69,738	114,055		183,793
1981	813	87,268	150,372		238,452
1982		107,898	239,696		347,595
1983	44	45,780	235,983		281,807
1984		127,432	284,431		411,864
1985		185,692	390,202		575,894
1986	80	123,419	395,851		519,350
1987		116,821	349,424		466,245
1988		14,570	389,382	302,670	706,622
1989		3,711	392,624	367,156	763,491
1990	94	25,835	272,274	366,236	664,439
1991		3,307	255,057	386,212	644,576
1992	168	10	281,380	392,607	674,165
1993	34	39,275	280,939	407,839	728,088
1994	65	852	270,793	395,443	667,153
1995				386,169	386,169
1996	0	12,686		430,447	439,165
1997	0	1,080		395,579	397,347
1998	5	25,528		324,957	336,096
1999	0	43,224		311,358	293,149
2000	0	2,316		289,966	271,654
2001	2	11,411		326,274	315,538
2002	154	2,607		309,098	295,617
2003	141	15,737		279,687	295,565
2004	53	1,826		287,732	289,611

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